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Lawrence Livermore National Laboratory

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UCRL-AR-116583

Remedial Design Report No. 5 for Treatment Facilities G-1 and G-2 Lawrence Livermore National Laboratory Livermore Site

May 1, 1995

Technical Editors

L. L. Berg*
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R. W. Bainer
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Environmental Protection Department

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Contents

List of Figures

List of Plates

List of Tables

Summary

This is the fifth of six Remedial Design reports that describe plans for implementing ground water and soil cleanup at the Lawrence Livermore National Laboratory (LLNL) Livermore Site. The cleanup has been divided into 9 geographic areas with 11 treatment facilities that are addressed by the Remedial Design reports. The U.S. Department of Energy (DOE) and LLNL are preparing these reports over a 5-year period. The sixth report, for the Building 518 Area in the southeastern portion of the Livermore Site, was added in December 1993 in consultation with the regulatory agencies. The cleanup plans described in each report are designed to optimize the overall site cleanup and be consistent with projected funding levels. The overall cleanup approach for the LLNL Livermore Site is defined in the Remedial Action Implementation Plan (Dresen *et al.*, 1993), which can be found in the Information Repositories located at the LLNL Visitors Center and at the Livermore Public Library.

This Remedial Design report is for Treatment Facilities G-1 and G-2 in the south-central portion of the Livermore Site, referred to as the Treatment Facility G Area. The primary soil and ground water contaminants in the Treatment Facility G Area are the volatile organic compounds trichloroethylene, perchloroethylene, chloroform, 1,1-dichloroethylene, carbon tetrachloride, 1,2-dichloroethylene, 1,1,1-trichloroethane, and trichlorotrifluoroethane.

The planned ground water extraction wellfields for Treatment Facilities G-1 and G-2 were developed using hydrogeologic and volatile organic compound data. Six hydrostratigraphic units have been identified in the Treatment Facility G Area, although volatile organic compounds are restricted to only two of these units. A hydrostratigraphic unit consists of sediments correlated on the basis of hydraulic properties.

Five extraction wells and 16 piezometers are planned in the Treatment Facility G Area. The extraction wells will be used to pump ground water to the treatment facilities, and piezometers will be used to measure well communication at various depths and distances from the extraction wells. Monitoring the water levels in piezometers provides information about the size of the area being affected by the ground water extraction. One of the extraction wells has been installed, and the remaining four wells are planned for phased installation in the future. This phased approach will help determine the actual versus the estimated effectiveness of the initial planned extraction wells and treatment systems before proceeding with subsequent phases.

Treatment Facilities G-1 and G-2 are identical skid-mounted facilities that can be moved to different well locations, as needed. Although Treatment Facilities G-1 and G-2 are expected to remain at their proposed locations for the duration of the cleanup, they are prototypes for additional portable less costly facilities that may be used throughout the Livermore Site. Both treatment facilities will consist of air strippers and, if necessary, an ion-exchange or chrominum reduction unit for metals treatment. Ground water will be pumped from the extraction wells to the air stripper. As the water passes through the air

stripper, a blower will aerate the water and strip the volatile organic compounds from it. The volatile organic compounds will be collected by filtering the air through granular activated carbon. The air stripper will remove all of the above-described compounds from the ground water except for metals including chromium, which will be removed by an ion-exchange unit or a hexavalent chromium reduction unit to reduce it to the trivalent state, if necessary.

Treatment Facilities G-1 and G-2 are designed to remediate up to 30 gallons per minute of ground water. Three ground water extraction wells are planned to supply water to Treatment Facility G-1, and two ground water extraction wells are planned for Treatment Facility G-2. As discussed in the Record of Decision and the Remedial Action Implementation Plan, the extraction wells will be installed at locations to remove the highest volatile organic compound concentrations and to achieve hydraulic control of the southern edge of the volatile organic compound plume. Treated ground water from these facilities will be discharged to the nearest storm drain. Alternatively, the discharge may be sent to the Recharge Basin under an existing permit, if approved by the California Regional Water Quality Control Board. Any contaminants that remain in the treated water will be at or below the limits set by the California Regional Water Quality Control Board, as specified in Waste Discharge Requirement Order No. 91-091 for the storm sewer, or Waste Discharge Requirement Order No. 88-075 for the Recharge Basin.

Treatment Facility G-1 is scheduled to become operational in April 1996, and startup of Treatment Facility G-2 is scheduled for August 1999. The estimated total design and construction costs for both facilities are about $1,560,000.

To monitor the progress of the cleanup and determine the size and shape of the area being affected by the extraction wells, DOE/LLNL will sample for volatile organic compounds and metals, including chromium, and monitor water levels in the wells and piezometers within the Treatment Facility G Area. Results of all treatment system, extraction well, and piezometer monitoring will be included in the LLNL Monthly, and/or Annual Reports as currently required by the regulatory agencies.

DOE/LLNL will manage the extraction wellfield by varying the rates and locations of ground water extraction. The goal is to maximize the rate of volatile organic compound mass removal, and ensure remediation of all portions of the plume that exceed drinking water standards. In addition, DOE/LLNL are evaluating reinjection of the treated water to accelerate the cleanup.

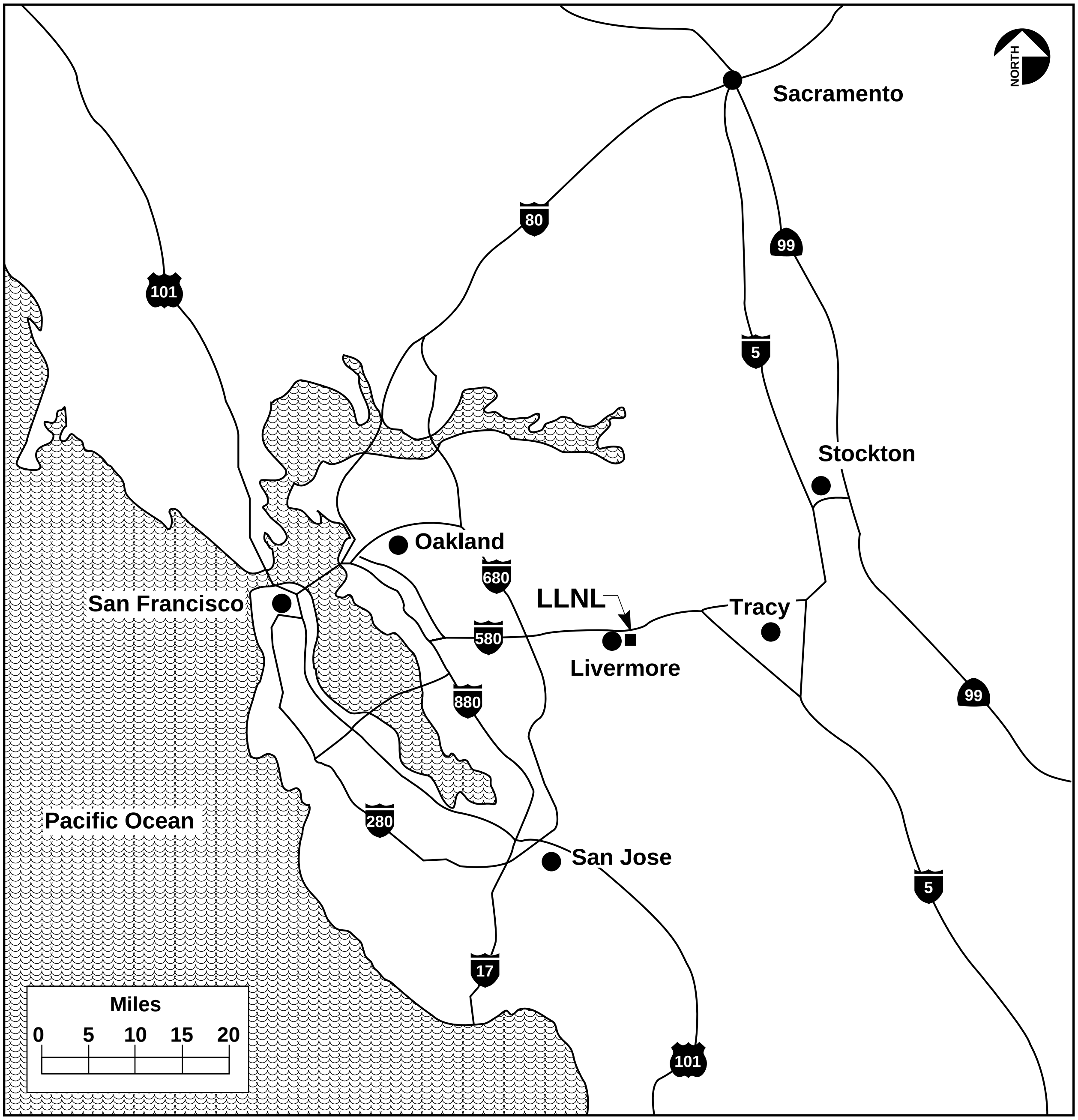
1. Introduction

This report is the fifth of six Remedial Design (RD) reports for the Lawrence Livermore National Laboratory (LLNL) Livermore Site, which is located about 40 miles east of San Francisco, California (Fig. 1). The sixth report, for the Building 518 Area in the southeastern portion of the Livermore Site, was added in December 1993 during consultation with the regulatory agencies. This RD report is for Treatment Facilities G-1 and G-2 (TFG-1 and TFG-2). TFG-1 and TFG-2 will be located in the south-central portion of the Livermore Site, referred to as the Treatment Facility G (TFG) Area (Figs. 2 and 3). As stated in the Remedial Action Implementation Plan (RAIP) (Dresen *et al.*, 1993), extraction locations 15 and 16 (Fig. 2) will be used to extract ground water in the TFG Area. The TFG Area is primarily located in a high-security area of LLNL that is extensively developed with buildings and underground utilities. Thus, for logistical and practical purposes, ground water will initially be treated at two, separate skid-mounted treatment facilities with shorter pipelines to the extraction wells rather than at a single larger facility with longer pipelines. Ground water extracted from location 15 will be treated at TFG-2, and ground water extracted from location 16 will be treated at TFG-1 (Fig. 2).

The six RD reports are being prepared over a 5-year period in accordance with a revised schedule in the RAIP (Dresen *et al.*, 1993). As described in the RAIP, the remedial actions presented in the Record of Decision (ROD) for the Livermore Site (DOE, 1992) will be phased-in to enable determination of the actual versus predicted effectiveness of the planned extraction and treatment systems prior to proceeding with subsequent phases and to be consistent with projected funding levels.

The Livermore Site was placed on the U.S. Environmental Protection Agency's (EPA's) National Priorities List in 1987. In November 1988, the U.S. Department of Energy (DOE), EPA, the California Department of Toxic Substances Control (DTSC), and the California Regional Water Quality Control Board (RWQCB) signed a Federal Facility Agreement (FFA) to facilitate compliance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended. As part of the CERCLA process, the LLNL Environmental Restoration Division (ERD) has prepared a series of documents: the Remedial Investigation (RI) (Thorpe *et al*., 1990) characterized the site hydrogeology and contaminant distribution; the Feasibility Study (FS) (Isherwood *et al*., 1990) screened and evaluated possible remedial alternatives; the Proposed Remedial Action Plan (Dresen *et al*., 1991) further evaluated conceptual remedial alternatives and recommended particular alternatives for ground water and soil cleanup; the ROD (DOE, 1992) codified and bound DOE and EPA to a cleanup approach for ground water and soil; and the RAIP (Dresen *et al*., 1993) presented the cleanup approach and a schedule for the remaining remedial actions.

As discussed in the ROD, the contaminants of concern at the Livermore Site are volatile organic compounds (VOCs), primarily trichloroethylene (TCE) and perchloroethylene (PCE); fuel hydrocarbons; tritium; and, possibly, chromium and lead. VOCs, and possibly chromium, are the only chemicals of concern at TFG-1 and TFG-2. The Applicable or Relevant and Appropriate Requirements (ARARs) for the Livermore Site are detailed in the FS and the ROD.



ERD-LSR-93-0110/RD5

Figure 1. Location of the LLNL Livermore Site.

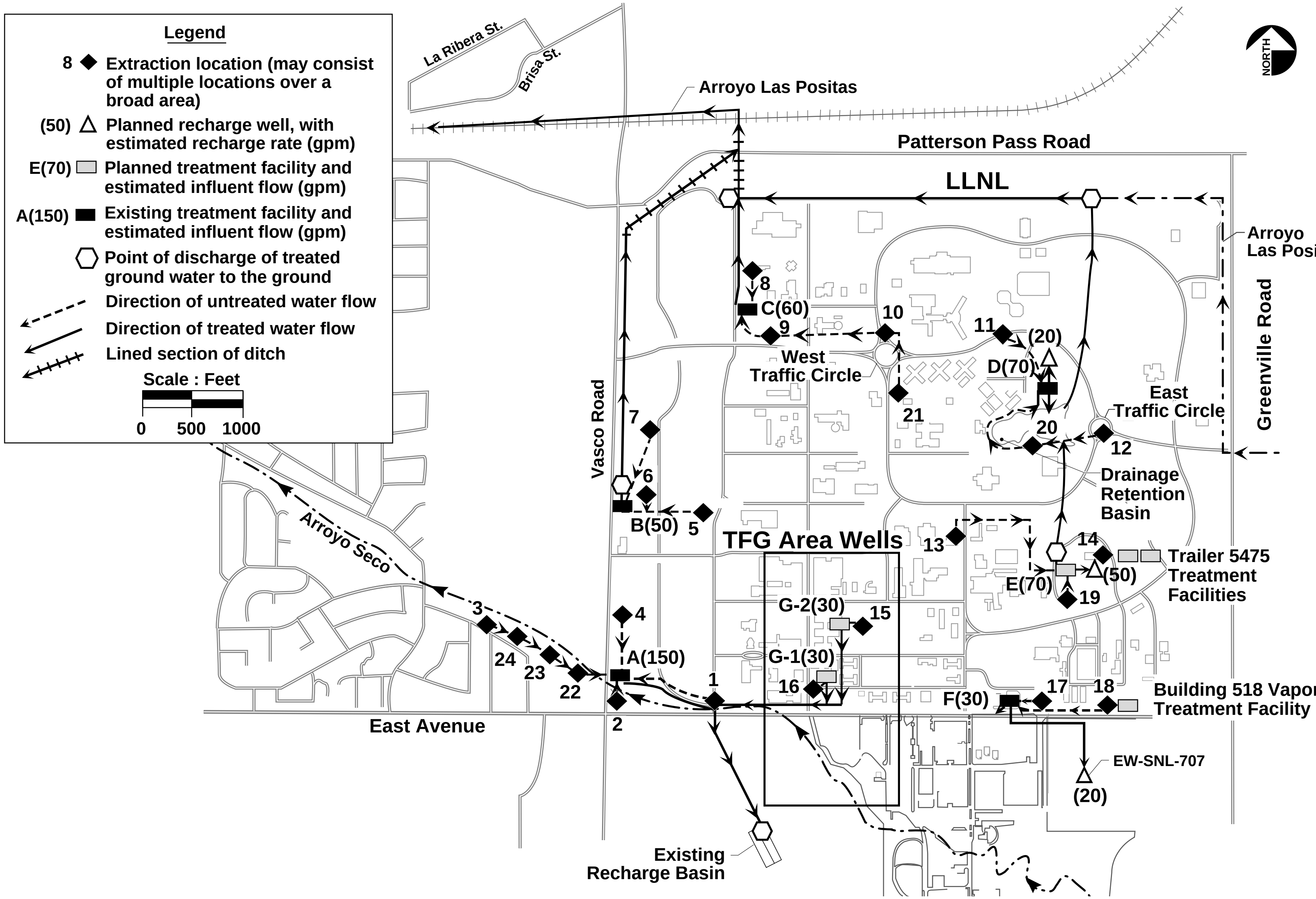


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Figure 2. Planned ground water and soil vapor extraction locations at the LLNL Livermore Site (modified from the RAIP).

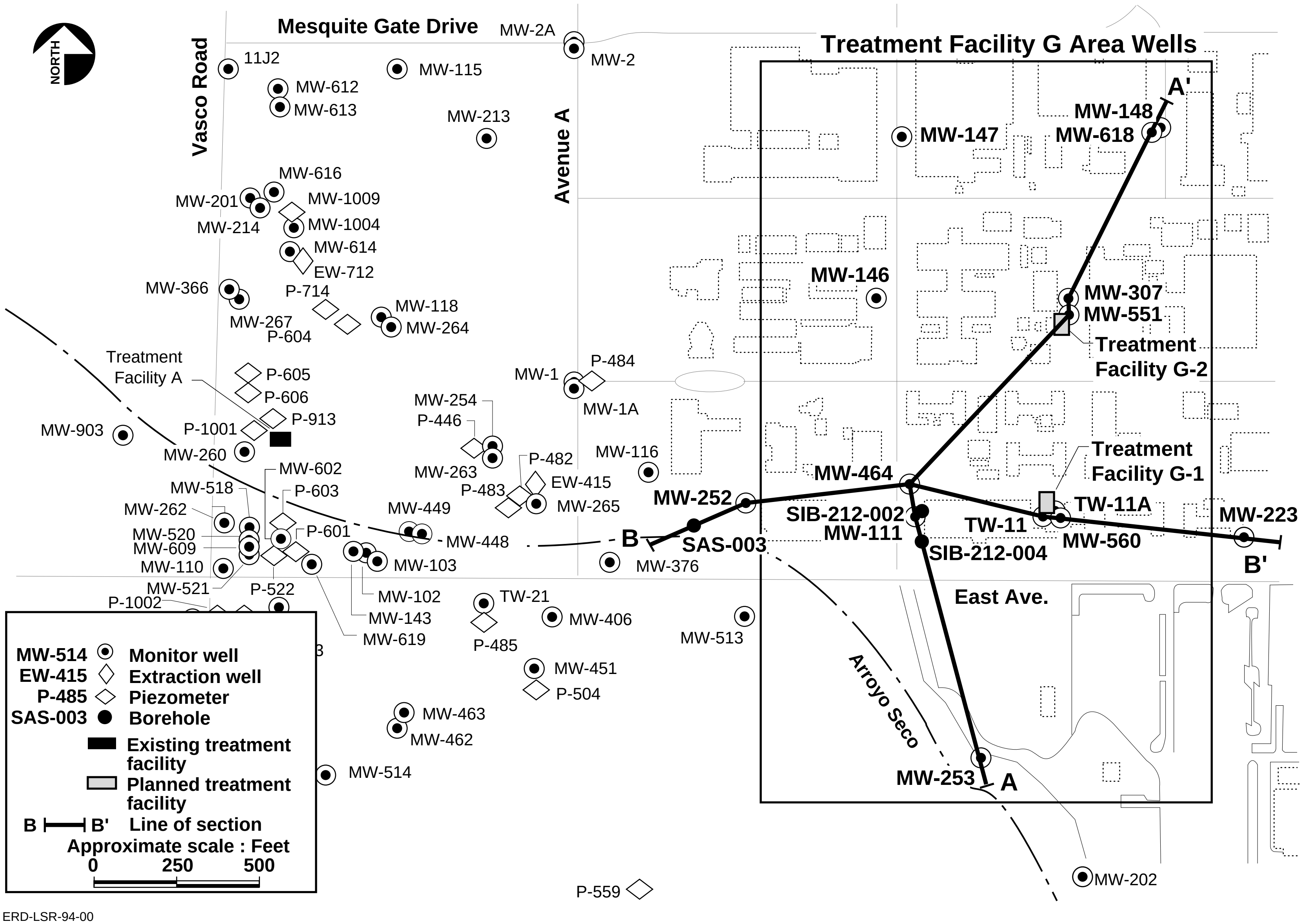

Figure 3. Monitor well, extraction well, piezometer, and borehole locations in the TFG Area.

The scope and format of this report are based on EPA guidance documents (EPA, 1989; 1990), an outline provided by EPA (Gill, 1993), and subsequent discussions with EPA. As specified by EPA, each RD report contains engineering design specifications for the ground water and/or vapor extraction and treatment systems, including piping and instrument diagrams (P&IDs), system descriptions, monitoring and construction schedules, and cost estimates. The RD reports also include a Remedial Action Work Plan that contains Quality Assurance/Quality Control (QA/QC) Plans and Health and Safety Plans (HASPs) for operation and maintenance, and the requirements for offsite shipment of hazardous waste and for project closeout. The QA/QC Plans and HASPs for construction are the same for all RD reports. Therefore, these documents were submitted only with Remedial Design Report No. 1 (RD1) (Boegel *et al*., 1993).

This document was prepared by LLNL for DOE with oversight from EPA, DTSC, and RWQCB. The six RD reports are primary documents under the FFA for the Livermore Site.

Section 2 of this report presents the hydrostratigraphy and wellfield designs for TFG-1 and TFG-2. Section 3 presents the remedial design for the treatment facilities. Both TFG-1 and TFG-2 will be identical, skid-mounted treatment facilities. Section 4 is the Remedial Action Work Plan for TFG-1 and TFG-2. Appendices A through E present the soil and ground water analytical results, waste discharge permits, the Operations and Maintenance (O&M) QA/QC Plan, O&M HASP, and sampling procedures for TFG-1 and TFG-2, respectively.

2. Wellfield Design

The TFG Area ground water extraction wellfield design is based on hydrostratigraphic analyses, and VOC and chromium distribution data. These are discussed in Section 2.1, and the extraction well and piezometer locations and design are presented in Section 2.2.

2.1. Hydrostratigraphic Analysis and VOC Distribution

2.1.1. Basis for Defining Hydrostratigraphic Units

For this RD report, hydrostratigraphic units were defined and used to design the TFG-1 and TFG-2 wellfields (Fig. 4). A similar approach was used in RD reports 3 and 6 to design the Treatment Facility D and E (TFD and TFE) and the Building 518 Vapor Treatment Facility wellfields. Conversely, RDs 1 and 2 utilized water-bearing zones as the basis to plan the wellfields. The use of hydrostratigraphic units reflects ongoing work to interpret and synthesize the Livermore Site hydrogeology on a site-wide scale, and is a logical progression from the use of borehole-specific water-bearing zones to more regional interpretations. The progression from the use of water-bearing zones to hydrostratigraphic units is discussed further below.

A water-bearing zone is defined at the Livermore Site as saturated permeable sediment greater than about 3 ft thick, separated from other permeable sediments above and below by at least 5 ft of low-permeability sediment. The water-bearing zones are numbered consecutively downward from ground surface at each borehole. During the hydrogeologic investigation

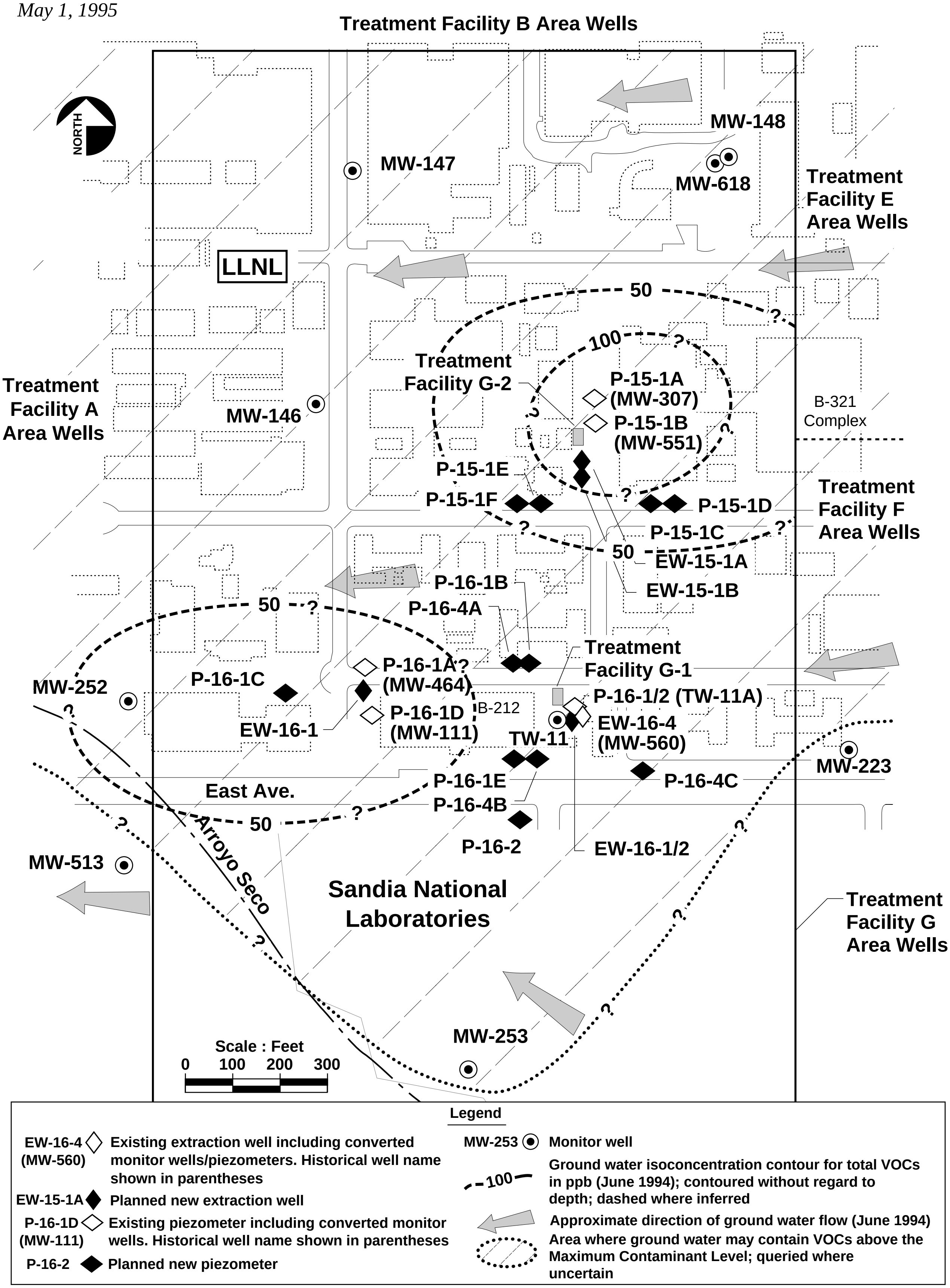

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Figure 4. Proposed TFG Area remedial wellfield design.

conducted for RD3 (Berg *et al.*, 1994), several of the water-bearing zones in the TFD and TFE Areas were identified as being hydraulically connected, based on pumping tests, chemical data, and geologic correlation. Hydrostratigraphic units consist of sediments grouped together primarily on the basis of their hydraulic properties.

The six hydrostratigraphic units previously defined in the TFD and TFE Areas have also been identified in the TFG Area. Hydraulic test analyses, soil and ground water chemical data, geologic core descriptions, and borehole geophysical logs were used to define the six hydrostratigraphic units in the TFG Area. VOC distribution and hydraulic properties within these units were analyzed to select the extraction well and piezometer locations. The primary purposes of TFG-1 Area extraction wells are to remove VOC mass and control the southern VOC plume margin. The primary purpose of TFG-2 Area extraction wells is to expedite cleanup by removing VOC mass.

Ten cross sections, incorporating hydrogeologic descriptions, geophysical logs, and soil and ground water chemical concentrations, were extended from the TFE Area to the TFG Area to design the extraction wellfields. Hydraulic communication data from pumping tests were also incorporated into the cross sections. Maps depicting geologic structure, unit thickness, hydraulic communication, VOC and chromium concentrations, and the potentiometric surface were then constructed for each hydrostratigraphic unit. The planned location and screened interval of each proposed extraction well and piezometer in the TFG-1 and TFG-2 Areas were determined by synthesizing the data presented on these maps and cross sections. DOE/LLNL will make available project files containing this hydrogeologic information upon request to the LLNL Area Public Relations Manager. After completion of all RD documents, a report is planned that will summarize the detailed analyses on which the hydrostratigraphy is based. Preliminary wellfield designs presented in RD reports may be modified based on new information or interpretations presented by DOE/LLNL or regulatory agencies.

2.1.2. Hydrostratigraphic Units in the TFG-1 and TFG-2 Areas

Figure 3 shows the lines of section for the TFG-1 and TFG-2 hydrostratigraphic interpretations presented in Figures 5 and 6. The first hydrostratigraphic unit (Unit 1) is a 60- to 90-ft-thick interval of interbedded sand, silt, clay, and gravel. The top of this unit is found from about 55 ft depth [570 ft above mean sea level (amsl)] in the southeast to over 105 ft (520 ft amsl) in the northwest, reflecting the general northwesterly dip of the sediments in the TFG-1 and TFG-2 Areas. High electrical resistivity geophysical log response and generally low gamma ray response are typical for the sands and gravels in this unit, with low resistivity and high gamma ray responses in the intervening silts and clays. Due to the relative small amount of hydraulic data in the TFG Area, the extent of lateral communication in Unit 1 is not known. However, based on correlating geophysical log response with Unit 1 hydraulic analyses in the TFD and TFE Areas, we anticipate good hydraulic communication (over 0.5 ft of drawdown between the sandy interbeds over a lateral distance of 400 ft) in the east-west direction. Although Unit 1 has a similar geophysical log signature as that in the TFD and TFE Areas, Unit 1 is thicker and contains more fine-grained interbeds in the TFG Area than in the eastern part of LLNL.

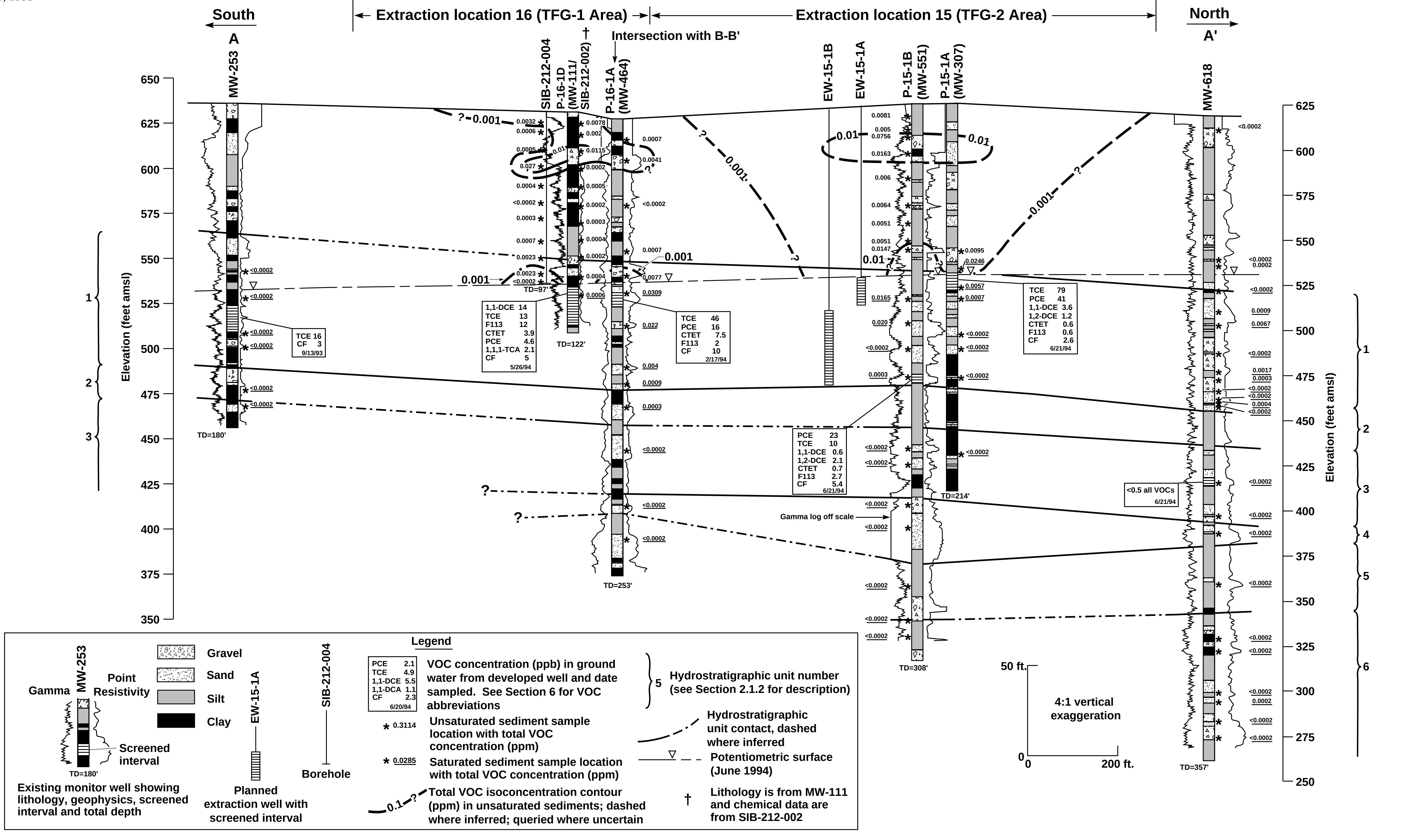
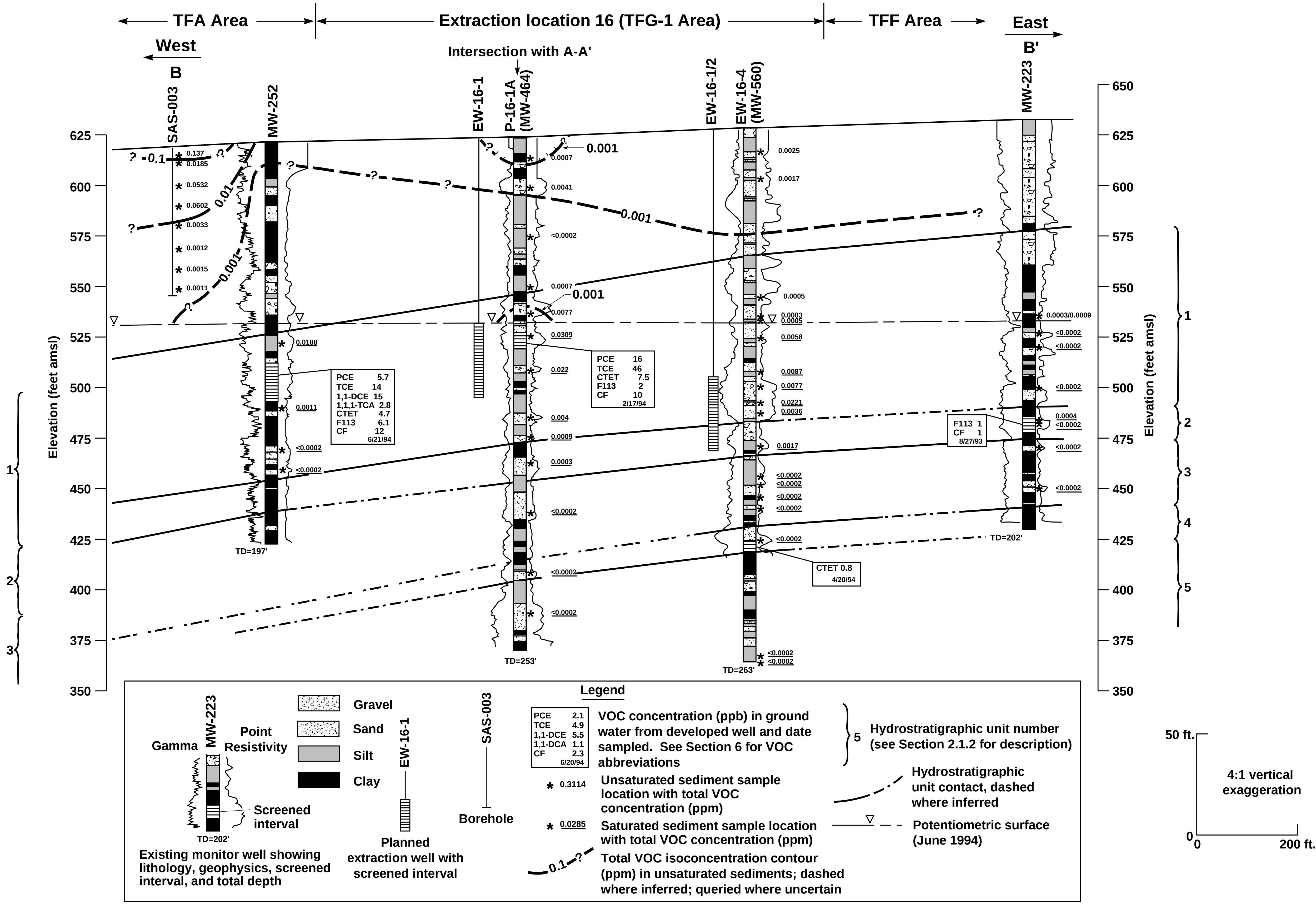


Figure 5. Hydrogeochemical and geophysical cross section A-A' and proposed remedial wellfield design in the TFG-1 and TFG-2 Areas.



RD5 cross section B-B'

Figure 6. Hydrogeochemical and geophysical cross section B-B' and proposed remedial wellfield design in the TFG-1 Area.

The top of the second hydrostratigraphic unit (Unit 2) occurs between depths of about 140 and 175 ft (485 and 450 ft amsl) and is about 15- to 30-ft thick in the TFG Area. Unit 2 consists predominantly of lower permeability silts, clayey silts, and clayey sands with at least one laterally continuous, permeable sand and gravel interbed in the eastern TFG-1 Area (Fig. 6). The geophysical response of this interbed is similar to the more laterally continuous sand interbeds observed in Unit 2 in the southwestern TFE Area. Therefore, good hydraulic communication is anticipated within this unit, similar to that observed in the southwestern TFE Area (over 0.5 ft of drawdown over a lateral distance of 400 ft). The contact between Units 1 and 2 is commonly marked by a change to predominantly finer grained sediments in Unit 2 and a decrease in VOC concentrations in saturated soil samples (Figs. 5 and 6). The geophysical logs generally reflect this lithologic change as an increased gamma ray response and a lower resistivity response compared to Unit 1.

The third hydrostratigraphic unit (Unit 3) is a 30- to 45-ft-thick sequence of lower permeability clayey silts and clayey sands, with 1- to 5-ft thick interbeds of sands and gravels. The top of Unit 3 occurs at depths of 160 to 185 ft (465 to 440 ft amsl). The higher permeability sand sequence comprising Unit 3 in the western TFE Area is not present in the TFG Area. Unit 3 consists of two fining-upward sequences with a characteristic increasing gamma ray and a decreasing resistivity response (see well MW-464 on Fig. 6). The top of the upper sequence forms the boundary between Units 2 and 3. To date, no VOCs have been detected in Unit 3 in the TFG-1 and TFG-2 Areas.

The fourth hydrostratigraphic unit (Unit 4) is a laterally continuous, 5- to 10-ft-thick, higher permeability sand and gravel unit that occurs on top of the Lower Member of the Livermore Formation. The top of Unit 4 is typically found at depths ranging from 185 to 230 ft (440 to 395 ft amsl). Geophysical logs, geologic core descriptions, and pumping test data indicate that this unit is thinner and less permeable than in the western portions of the TFD and TFE Areas. Sustainable flow rates are anticipated to range between 5 and 10 gallons per minute (gpm). Based on limited pumping test data, a high degree of lateral hydraulic continuity is expected within Unit 4 across both the TFG-1 and TFG-2 Areas. Although no VOCs were found above detection limits in Unit 4 sediments, ground water chemical analyses report carbon tetrachloride ranging from 0.5 to 2 parts per billion (ppb) in well MW-560 since 1989 (0.8 ppb reported April 20, 1994). The Maximum Contaminant Level (MCL) for carbon tetrachloride is 0.5 ppb.

The fifth hydrostratigraphic unit (Unit 5) is the uppermost part of the Lower Member of the Livermore Formation. This unit is equivalent to the transition zone between the Upper Member of the Livermore Formation and the green and blue units below (Thorpe *et al.*, 1990). Unit 5 is about 20 to 50 ft thick, and its top occurs at depths from 210 to 255 ft (415 to 370 ft amsl) in the TFG-1 and TFG-2 Areas. Unit 5 consists predominantly of fine-grained, mottled greenish-gray to yellow-brown silt and clay with interbeds of silty to clayey gravels and sands. The laterally continuous, coarse-grained permeable sediments that form the base of this unit over much of the TFD and TFE Area are present in well MW-551 in the TFG Area (Fig. 5). Elevated gamma ray response, accompanied by a subdued resistivity response, is typical of Unit 5 fine-grained sediments. The basal sand layer, where present, exhibits a low gamma ray response and a high resistivity response. No VOCs have been observed above the detection limit in Unit 5 sediments or ground water in the TFG-1 or TFG-2 Areas.

The upper portion of the sixth hydrostratigraphic unit (Unit 6) consists of low-permeability, light-green silty clay to clayey silt, with minor interbeds of clayey sand and gravel. The top of Unit 6 occurs at depths of 280 to 290 ft (345 to 335 ft amsl). This upper sequence in Unit 6 forms a regional confining layer throughout the Livermore Site area. This unit is equivalent to the green unit in the Lower Member of the Livermore Formation (Thorpe *et al.,* 1990). Elevated gamma ray response reflects the higher clay content within this unit. Based on field descriptions and laboratory tests, the clay unit exhibits very low hydraulic conductivity, on the order of 10^{-7} to 10^{-8} centimeters per second (3.3 x 10^{-9} to 3.3 x 10^{-10} feet per second). Limited data indicate that laterally continuous, high-permeability gravel units occur below this clay layer. No VOCs have been detected in Unit 6 soil or ground water in the TFG-1 or TFG-2 Areas except for 0.0002 parts per million (ppm) 1,2-dichloroethylene (1,2-DCE) in a saturated soil sample collected from a depth of 326 ft (293 ft amsl) from the borehole for MW-618. The absence of VOCs in all other Unit 5 and Unit 6 ground water and soil samples from the TFG-1 and TFG-2 Areas, strongly indicates that the reported 1,2-DCE is a laboratory error and that VOCs are not in the confining layer.

2.1.3. VOC Distribution

Building 212 and Building 321 in the TFG Area were identified as potential source areas in the RI (Thorpe *et al.*, 1990). Building 212 was constructed and used by the U.S. Navy in the early 1940s as a drill hall and gymnasium. Starting in the early 1950s this building was used for accelerator research. This research program ended and all of the equipment was removed by the early 1990s. Past releases probably occurred from leaking drums, plating shop spills, and a cold trap cleaning area. Construction of the Building 321 Complex began in 1954 with subsequent additions through 1985. The complex has housed various machine, plating, and small support shops. Releases probably occurred from plating shop sumps and spills, and storm drains which may have received coolant and oils. As concluded in the RI, the small releases and low VOC concentrations in unsaturated sediments at Buildings 212 and 321 do not currently contribute significant quantities of VOCs to the ground water.

The interpreted distribution of total VOCs in unsaturated sediment in the TFG-1 and TFG-2 Areas are shown on Figures 5 and 6. Unsaturated sediment chemical data indicate that the highest reported VOC concentrations in the TFG-1 and TFG-2 vadose zone occur at 19.5 ft (605.5 ft amsl) in well MW-551, where 0.0756 ppm total VOCs, consisting of TCE, PCE, and carbon tetrachloride are reported (Fig. 5). These low VOC concentrations indicate there are no known active potential VOC sources in this area (Thorpe *et al.*, 1990). Therefore, no vadose zone remediation is planned in the TFG-1 or TFG-2 Areas.

Saturated sediment VOC concentrations in the TFG-1 and TFG-2 Areas are also depicted on Figures 5 and 6. Other than the anomalous Unit 6 soil analysis in well MW-618 discussed in Section 2.1.2, all reported VOCs in saturated sediment are confined to Units 1 and 2 in the TFG-1 Area and to Unit 1 in the TFG-2 Area. Chloroform has not been included in the total sediment VOC concentrations cited in this report because chlorinated drinking water is used to mix the drilling mud.

The highest total VOC ground water concentration in the TFG-1 and TFG-2 areas occurs in well MW-307 (Figs. 4 and 5), where 128.6 ppb total VOCs consisting of TCE, PCE, 1,1-dichloroethylene (1,1-DCE), 1,2-DCE, trichlorotrifluoroethane (Freon 113), chloroform, and carbon tetrachloride, were detected in June 1994. As indicated on Figure 4, at least one VOC exceeds its MCL in ground water across most of the TFG Area.

2.2. Extraction Wells and Piezometers

To estimate the hydraulic capture areas of the planned 24 ground water extraction locations shown in the RAIP, ground water flow paths were calculated using the numerical model CFEST (Coupled Fluid, Energy, and Solute Transport; Gupta *et al.*, 1987). Ground water extraction at the 24 planned extraction locations, and recharge at 2 planned injection wells, the Recharge Basin, and the Treatment Facility B and C drainage ditches, were simulated using the two-dimensional numerical flow model. The results of the simulation are shown in Figure 7.

Previous estimates of ground water capture zones presented in the ROD (DOE, 1992) and the RAIP (Dresen *et al.,* 1993) were calculated using the two-dimensional analytical flow model CAPTURE (McEdwards, 1986). Unlike the previous CAPTURE model, the CFEST results shown in Figure 7 incorporate the effects of aquifer recharge and heterogeneities, such as varying permeability and aquifer thickness. The development and results of the CFEST model are discussed in more detail in Tompson *et al.* (in preparation).

As stated in the RAIP (Dresen *et al.*, 1993), extraction locations 15 and 16 (Fig. 2) will supply ground water to TFG. Further analysis conducted since the RAIP for this RD indicate that it is more cost effective to treat this water at two separate, skid-mounted facilities rather than at a single facility. Ground water from extraction location 15 will be treated at TFG-2, and ground water from extraction location 16 will be treated at TFG-1 (Fig. 2).

2.2.1. Extraction Well Location and Design

Five extraction wells are planned in the TFG Area. One of these wells is currently installed, and the remaining four are planned for phased installation in the future. The phased approach will help to determine the actual effectiveness, compared to the estimated effectiveness, of the initial planned extraction wells and treatment systems before proceeding with subsequent phases. Design specifications for the TFG-1 and TFG-2 extraction wells are presented in Table 1; extraction well locations are shown on Figure 4. Extraction wells will be designed and constructed according to the principles specified in the RAIP (Dresen *et al.*, 1993).

Three of the five planned extraction wells are located in the TFG-1 Area (Fig. 4). Extraction well EW-16-1, located about 50 ft west of Building 212 (B-212) (Fig. 4), will remove VOCs from the first hydrostratigraphic unit where total VOC concentrations currently exceed 80 ppb (February 1994 data). EW-16-1/2 is located about 75 ft east of Building 212, and will capture VOCs in the deeper portion of the first hydrostratigraphic unit and in the upper portion of the second hydrostratigraphic unit. As discussed in the RAIP, if VOC concentrations in these two intervals are not within one order of magnitude in the EW-16-1/2 borehole, separate extraction wells may be installed in each hydrostratigraphic unit, or a bentonite/grout seal will be placed between the two screened intervals in EW-16-1/2 to inhibit vertical migration of VOCs when the well is not pumping and to prevent communication between zones when one zone is selectively pumped. EW-16-1/2 may be also completed with a bentonite seal if a confining zone 3 ft thick or greater occurs between the two intervals.

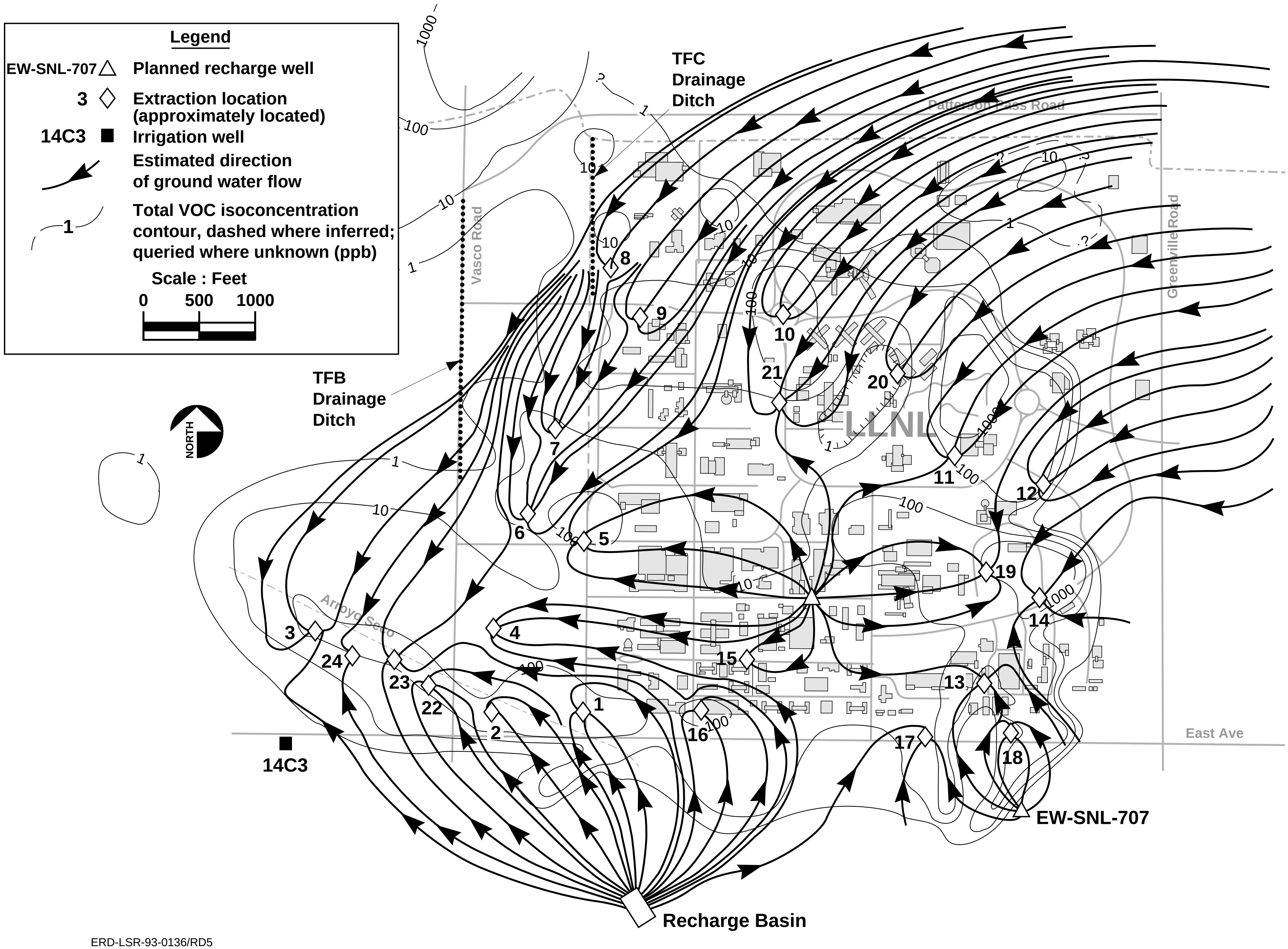


Figure 7. Estimated hydraulic capture zones and recharge well locations.

Table 1. TFG-1 and TFG-2 extraction well specifications.

Well name	Extraction well name[a]	Well design[b]	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	Sand-pack interval (ft)	Hydro-stratigraphic unit[c]	Estimated maximum long-term steady state yield (gpm)[d]	Pump type[e]	Pump intake depth (ft)	Activation priority[f]
TFG-1 Area												
Extraction location 16												
TBI	**EW-16-1**	**Single**	**–**	**(130)**	**(127)**	**(90-127)**	**(88-127)**	**First**	**(5-10)**	**–**	**124**	**1**
TBI	**EW-16-1/2**	**Multiple**	**–**	**(170)**	**(160)**	**(125-160)**	**(122-160)**	**First & second**	**(5-15)**	**–**	**143**	**4**
MW-560	**EW-16-4**	**Single**	**07-Feb-89**	**263.0**	**206.5**	**201-206.5**	**199-208**	**Fourth**	**2-5**	**16S10-10**	**201**	**5**
TFG-2 Area												
Extraction location 15												
TBI	**EW-15-1A**	**Single**	**–**	**(125)**	**(120)**	**(95-120)**	**(93-120)**	**First**	**(2-5)**	**–**	**117**	**3**
TBI	**EW-15-1B**	**Single**	**–**	**(160)**	**(155)**	**(120-155)**	**(116-155)**	**First**	**(20-25)**	**–**	**(140)**	**2**

Notes:

TBI = To be installed.

Estimates are shown in parentheses.

[a] **Extraction well name indicates location, as shown in Figure 2 (i.e., EW-15-1A is at extraction location 15), and the hydrostratigraphic unit monitored (i.e., EW-15-1A is screened in the first unit). When multiple extraction wells are screened in the same hydrostratigraphic unit, a letter follows the unit designation (i.e., EW-15-1A, EW-15-1B, etc.). Figure 4 shows planned extraction well locations.**

[b] **The two extraction well designs are:**
Single = a well screened and sand-packed in only one water-bearing zone.
Multiple = a fully screened and sand-packed well in multiple water-bearing zones.
Additional information regarding these well designs and their applications is presented in the RAIP (Dresen *et al*., 1993).

[c] **Numbered consecutively downward from ground surface at each extraction location. A hydrostratigraphic unit is defined as sediments grouped together on the basis of hydraulic properties, geologic, geophysical, and/or chemical data.**

[d] **Estimated yield based on pumping test results. Actual long-term pumping rates will generally be lower. Where an extraction well is not yet installed, estimates of sustainable flow rates are shown in parentheses. These are based on the flow rates from nearby wells screened in similar zones and/or the thickness and estimated permeability of sediments in the area.**

[e] **Grundfos stainless steel submersible pump currently installed. Nominal pump flow rate is 14 gpm at 250-ft head.**

[f] **Activation priority is the estimated order in which extraction wells will be connected to the treatment facility. Activation priority is based on whether the well currently exists, engineering design and cost, and the known or anticipated VOC concentration in ground water at the extraction locations.**

Existing monitor well MW-560, about 100 ft east of Building 212, may be converted to extraction well EW-16-4 to remove ground water from the fourth hydrostratigraphic unit where 0.8 ppb carbon tetrachloride (slightly above the 0.5 ppb MCL) has been reported. The carbon tetrachloride appears to be localized and has not significantly increased since installation of MW-560 in 1989. No other detectable VOCs have been observed in the fourth hydrostratigraphic unit in TFG Area wells. We plan to continue monitoring MW-560 carbon tetrachloride concentrations for one to two years after the shallower wells are pumping to determine whether the fourth hydrostratigraphic unit is affected. If the concentration of carbon tetrachloride does not decrease after this monitoring period, DOE/LLNL and the regulatory agencies will then discuss any necessary remedial options. If VOCs fall below MCLs, we will not pump EW-16-4 or install the piezometers.

Well MW-253, located south of East Avenue on DOE property administered by Sandia National Laboratories (Fig. 4), is screened in Unit 2 and contained 16 ppb TCE in September 1993. This exceeds the 5 ppb MCL for TCE. The origin of this TCE is unknown at this time. However, potentiometric maps for Units 1 and 2 show that ground water flow is northwestward from this well toward the Livermore Site, making it unlikely that the source of this TCE is from the TFG-1 Area. We plan to monitor drawdown in MW-253 and in proposed piezometer P-16-2 to determine whether pumping EW-16-1/2 will affect MW-253.

Two new extraction wells are planned for the TFG-2 Area (Fig. 4). Because VOCs above the detection limit are confined to Unit 1 at extraction location 15, both planned wells will be completed in this unit. Extraction wells EW-15-1A and EW-15-1B will be located adjacent to each other about 100 ft west of the Building 321 (B-321) Complex (Fig. 4), where VOCs consisting of primarily TCE and PCE are present. Extraction well EW-15-1A will be screened in lower permeability sediments in the upper part of Unit 1, and EW-15-1B will be screened in three higher permeability sand and gravel zones in the lower part of Unit 1. We plan to screen these two intervals in separate wells because of the possibility that VOCs with greater than an order of magnitude difference in concentration will be found in the two intervals, and to enable greater control over the extraction rates from the two intervals (the less transmissive upper interval should yield less water than the lower more transmissive interval at a given drawdown from a single extraction well). If sampling of the first pilot borehole indicates that VOCs are within an order of magnitude in the two intervals, then the well will be screened over the entire interval, eliminating the necessity of a second extraction well.

In the RAIP (Dresen *et al.*, 1993), the influent flow rate for TFG was estimated at 40 gpm. The more detailed analyses conducted for this RD report indicate that sustainable extraction flow rates may be higher as a result of installing more extraction wells than originally estimated. In addition, properly designed extraction wells are more efficient and may have longer screened intervals than most of the existing monitor wells. Therefore, flow rates higher than those observed from hydraulic tests conducted on the existing monitor wells may be expected, especially in the early phases of pumping. Table 1 shows the estimated maximum sustainable yields from each TFG-1 and TFG-2 extraction well based on the most recent hydraulic and hydrogeologic data. Because no long-term pumping data exist for either area, the estimates in Table 1 probably represent upper bounds for steady-state yields. These upper bounds are shown on Table 1 so that pumps with adequate capacity can be installed. The estimated maximum long-term steady-state yields of TFG-1 and TFG-2 Area wells in Table 1 total 60 gpm. In most cases, as long-term ground water extraction progresses, flow rates will decline as shallow sediments dewater, distant hydraulic boundaries are encountered, pumping of other wells in the vicinity begins, and/or local gradients decrease. Based on data from extraction well EW-415 in southwestern LLNL, the long-term total yield of TFG-1 and TFG-2 extraction wells may be about 30 to 40 gpm. As discussed in Section 3.1.1, the two skid-mounted treatment facilities will be designed to treat an initial flow of 30 gpm each, with the flexibility to expand to accommodate larger flows, if needed.

Pumping at extraction location 16 will begin with well EW-16-1, and pumping at extraction location 15 will begin with well EW-15-1B (Table 1). The other planned extraction wells will be added as funding permits. Extraction flow rate and ground water elevation and chemistry data will be collected to determine if the planned extraction scenario is capturing the 100 ppb total VOC contour at extraction location 15 (Fig. 4). If actual TFG-2 flow rates are substantially lower and result in incomplete capture of the 100 ppb contour, additional extraction wells may be considered. Water levels will be monitored in MW-253 during pumping of EW-16-1/2. If no hydraulic response occurs at MW-253, additional extraction wells located to the south may be needed. The locations of any new wells would be based on field water level data and recalibrated modeling results, and subject to regulatory agency review.

2.2.2. Piezometer Location and Design

Piezometers near the extraction wells will be monitored to determine the extent of hydraulic capture and identify potential areas of little or no ground water flow. The TFG-1 and TFG-2 Area piezometer configuration is designed to monitor the cumulative drawdown for each hydrostratigraphic unit, rather than the drawdown achieved by individual extraction wells. Thus, some piezometers will monitor multiple extraction wells.

TFG-1 and TFG-2 Area piezometer locations (Fig. 4) are based primarily on information from available hydraulic test data. In areas where low sustainable yields are anticipated, we plan to locate the additional proposed piezometers closer to the extraction wells, commonly within about 100 ft. Whenever possible, existing monitor wells were incorporated into the piezometer network. Up to 16 piezometers (5 existing and 11 new) are planned in the TFG Area. Preliminary design specifications for the new piezometers, along with the design specifications of the existing piezometers, are presented in Table 2. The ground water chemistry monitoring plan for the TFG Area is presented in Section 4.2.2.

3. Remedial Design

TFG-1 and TFG-2 will be ground water treatment facilities located in the south-central portion of the Livermore Site (Fig. 2). The principal compounds of concern in the TFG Area are TCE, PCE, chloroform, carbon tetrachloride, 1,1-DCE, Freon 113, 1,1,1-trichloroethane (1,1,1-TCA), 1,2-DCE, and possibly chromium (see Table 3 in Section 3.1.1). TCE, PCE, 1,1-DCE, and carbon tetrachloride exceed their respective MCLs. TFG-1 and TFG-2 will be identical skid-mounted treatment facilities. TFG-1 and TFG-2 will consist of commercially available air strippers to treat VOCs and, if needed, a commercially available ion-exchange unit, or a hexavalent chromium reduction unit. The air stripper effluent vapor stream will pass through granular activated carbon (GAC) to remove any residual VOCs. The treated ground

Table 2. TFG-1 and TFG-2 piezometer specifications.

Well name	Piezometer name[a]	Date completed	Borehole depth (ft)	Casing depth (ft)	Perforated interval[b] (ft)	Sand-pack interval (ft)	Approximate flow rate (gpm)	Activation priority[c]
TFG-1 Area								
Extraction location 16								
MW-464	P-16-1A	30-Sep-88	253.0	104.5	96-104.5	89-105	2	1
TBI	P-16-1B	–	(170)	(140)	(130-140)	(128-140)	(5)	13
TBI	P-16-1C	–	(130)	(105)	(100-105)	(98-105)	(2)	6
MW-111	P-16-1D	02-May-85	122.0	117.0	97-117	94-117	1	2
TB1	P-16-1E	–	(170)	(140)	(130-140)	(128-140)	(5)	7
TW-11A	P-16-1/2	16-Mar-84	163.0	160.0	133-160	121-163	6	3
TBI	P-16-2	–	(140)	(130)	(120-130)	(118-130)	(2)	8
TBI	P-16-4A[d]	–	(220)	(210)	(200-210)	(198-210)	(2)	16
TBI	P-16-4B[d]	–	(220)	(210)	(200-210)	(198-210)	(2)	14
TBI	P-16-4C[d]	–	(210)	(205)	(195-205)	(193-205)	(2)	15
TFG-2 Area								
Extraction location 15								
MW-307	P-15-1A	15-Dec-86	214.0	102.0	93-102	89-102	<1	4
MW-551	P-15-1B	18-Oct-88	308.0	155.5	151-155.5	148-155	20	5
TBI	P-15-1C	–	(125)	(120)	(110-120)	(108-120)	(1)	12
TBI	P-15-1D	–	(160)	(130)	(120-130)	(118-130)	(15)	10
TBI	P-15-1E	–	(125)	(120)	(110-120)	(108-120)	(1)	11
TBI	P-15-1F	–	(160)	(130)	(120-130)	(118-130)	(15)	9

Notes:

TBI = To be installed.

Estimates are shown in parentheses.

[a] Piezometer names indicate their location as shown in Figure 2 (i.e., P-16-1A is at extraction location 16) and the hydrostratigraphic unit monitored (i.e., P-16-1A is screened in the first unit). Letters following the unit designation indicate that multiple piezometers are screened in that unit (i.e., P-16-1A, P-16-1B, etc.). Figure 4 shows planned piezometer locations.

[b] The perforated interval listed for piezometers not yet installed is the perforated interval of the extraction well they are designed to monitor. These estimates are shown in parentheses. The actual perforated interval will be based on the hydrostratigraphy and chemistry encountered during drilling.

[c] Piezometer activation is prioritized according to the activation of the associated extraction well(s).

[d] These piezometers will be installed only if long-term pumping is necessary at EW-16-4.

water will be discharged to the storm sewer and will meet the discharge requirements specified in RWQCB Waste Discharge Requirement (WDR) Order No. 91-091 [National Pollutant Discharge Elimination System (NPDES) Permit No. CA 0029289] for discharge to the storm sewer (Appendix B). Alternatively, the discharge may be sent to the Recharge Basin under WDR Order No. 88-075 (Appendix B) if approved by the RWQCB. The treated water may also be used for onsite irrigation or in the LLNL cooling towers.

3.1. Specifications, Design, Treatability Tests, Controls, and Safeguards

The specifications, design, treatability tests, controls, and safeguards for TFG-1 and TFG-2 and associated piping are described in Sections 3.1.1 through 3.1.3.

3.1.1. Specifications and Design

TFG-1 and TFG-2 are each designed to treat 30 gpm of ground water at the expected influent concentrations, although the air stripper is capable of treating flows up to 45 gpm. As cleanup progresses and VOC concentrations decrease, the system can then treat greater flows. LLNL engineers will evaluate each treatment system during operation to determine the optimal flow rate by monitoring VOC concentrations versus air/water flow ratio. Initially, TFG-1 and TFG-2 will operate during working hours, until 24-h/day operation is logistically feasible. VOCs and possibly chromium are the constituents to be remediated at TFG-1 and TFG-2. Design influent concentrations and effluent discharge requirements are shown in Table 3. The design VOC influent concentrations are based on recent data (April 1994) from wells in the newly defined extraction locations, and differ slightly from the estimated total VOC influent concentrations in the RAIP (Dresen *et al*., 1993) and FS (Isherwood *et al.*, 1990). Average influent concentrations were determined by calculating the mass removal rates for individual constituents from each well, and dividing the cumulative mass removal rate from all wells by the combined estimated influent flow rate. Sitewide total chromium and hexavalent chromium data indicate that virtually all of the total chromium, which may be naturally occurring in the LLNL vicinity, is hexavalent.

The process equipment at TFG-1 and TFG-2 will be designed to prevent inorganic ground water constituents from causing excessive system component degradation. The materials used are not affected by the low VOC concentrations or inorganic ground water constituents. Scaling can generally be controlled by routine cleaning. If necessary, acid, carbon dioxide, sequestering agents, or other methods will be used to control scaling. Table 4 presents average inorganic chemistry data, collected since 1988, for TFG-1 and TFG-2.

RWQCB WDR Order Nos. 91-091 and 88-075 (Appendix B) limit effluent concentrations to 5 ppb total VOCs (Table 3). Effluent concentrations for hexavalent chromium are limited to 11 and 500 ppb in WDR Order Nos. 91-091 and 88-075, respectively (Table 3). Bay Area Air Quality Management District's (BAAQMD) Best Available Control Technology (BACT) guidelines (BAAQMD, 1992) are met if VOC emissions to the atmosphere are less than 6 parts per million on a volume per volume basis ($ppm_{V/V}$). BAAQMD issued an "Authority to Construct" for TFG-1 and TFG-2 on March 17, 1994.

Table 3. TFG-1 and TFG-2 design influent concentrations (as of April 1994).

Constituent	Concentration (ppb)			
	TFG-1 average influent	TFG-2 average influent	WDR Order No. 91-091 effluent discharge requirements	WDR Order No. 88-075 effluent discharge requirements
PCE	13	22	4	5[a]
TCE	38	17	5[a]	5[a]
1,1-DCE	11	1	5[a]	5[a]
1,2-DCE (total)	<1	2	5[a]	5[a]
1,1,1-TCA	3	<1	5[a]	5[a]
Carbon tetrachloride	12	1	5[a]	5[a]
Chloroform	15	4	5[a]	5[a]
Freon 113	7	3	5[a]	5[a]
Total VOCs	99	50	5[b]	5[b]
Total chromium	21	9	50	1,700
Hexavalent chromium	___[c]	<10	11	500

[a] There are no individual discharge limits for these VOCs, but they are included in WDR Order Nos. 91-091 and 88-075 under the 5 ppb total VOC discharge limit.

[b] Total VOC discharge limit as specified in WDR Order Nos. 91-091 and 88-075.

[c] Hexavalent chromium data are not available.

Table 4. TFG-1 and TFG-2 inorganic ground water chemistry influent concentrations since 1988.

Constituent/parameter	Average influent concentration (ppm)	
	TFG-1	TFG-2
pH	7.6 (pH units)	7.6 (pH units)
Sodium	68	73
Calcium	57	68
Magnesium	24	30
Bicarbonate	320	407
Chloride	39	66
Nitrate	34	19
Sulfate	43	31
Potassium	2	2
Carbonate	<0.6	<0.6
Total dissolved solids	497	519
Iron	<0.05	<0.04
Manganese	<0.05	<0.04

The specifications and design for TFG-1 and TFG-2 are discussed below. The equipment specifications are presented in Table 5. Location plans and a P&ID are presented as Plates 1 and 2*, respectively.

Table 5. TFG-1 and TFG-2 equipment specifications.

Equipment	Specifications
TFG-1/TFG-2 Building	Cargo-type shipping container, 19.5- × 7.8- × 7.8-ft inside dimensions
Stainless steel extraction well pumps	Grundfos model numbers 5S05-9, 10S05-9, 16S10-10, 25S20-11, or equivalent. Well MW-560 has a Grundfos 16S10-10, 1 horsepower (hp) pump capable of 14 gallons per minute (gpm) at 250-ft head. A Grundfos 5S05-9, 0.5-hp pump, is capable of 4 gpm at 200-ft head; Grundfos 10S05-9, 0.5-hp pump, is capable of 8 gpm at 200-ft head; and Grundfos 25S20-11, 2-hp pump, is capable of 20 gpm at 250-ft head
Influent pipeline from extraction wells to TFG-1/TFG-2	Schedule 80 polyvinyl chloride, 1- to 3-in. inside diameter, doubly contained pipe where visual access is not possible
Leak detection system for doubly contained underground piping to extraction wells that cannot be visually inspected (if needed)	As required, Trace Tek 300 Longline system, Raychem Corporation, or equivalent
Particulate filter canister	Cuno Model No. 12 DC3, stainless steel, 230-gpm maximum, or equivalent, 150 psi maximum operating pressure at 200°F
Particulate filter cartridges	Cellulose cartridges or equivalent nominal 5-micron filter
Air stripper	Shallow-tray Model No. 2331, 45 gpm maximum flow rate, 300 cubic feet per minute (cfm) maximum at 18-in. water column, inlet screen and damper, 316L stainless steel demister or equivalent. Supply blower is an American Fan Co., A. F. Model VP-1-06-18.5A, 5 hp, 3,500 revolutions per minute (rpm), 3 phase, 208 volts alternating current, totally closed fan-cooled motor or equivalent
Stripper sump level control sensor (if needed)	MTS magnetic level sensor or equivalent
Discharge pump and motor	Bell and Gossett pump Series 15120-11/2 BC, 3-5 hp, 1,750 rpm, 208 volts alternating current, 60 hertz, 3-phase motor with 5 to 45 gpm at 100-ft total dynamic head, or equivalent
Variable speed control unit (if needed)	Yokogawa single loop PID controller, or equivalent, to control flow from 5 to 50 gpm
Variable frequency drive (if needed)	Baldor series 15 variable frequency drive inverter or equivalent
Vapor phase GAC	Carbtrol Model No. G3S (steel), 140 lb carbon, 4.5 in. water at 450 cfm, or equivalent, 4-in. inlet/outlet connections
Ion-exchange canister (if needed)	Purolite A-600, or equivalent ion-exchange resin, or equivalent technology
pH adjustment and monitor (if needed)	Acid or carbon dioxide system, or equivalent method
Programmable logic controller	486 personal computer with Paragon control software and OPTO-22 I/O, or equivalent
Water flow meters	Krohne Magmeter Model No. IFM1080K with wafer process connections, 24 volts direct current power supply and transmitter, flow range as appropriate for the individual extraction well
Submersible pressure transducers	Model PS9000, or equivalent, 4- to 20-milliamp output, pressure range as appropriate for the individual extraction well

* Plates 1 and 2 are located in a pocket inside the back cover of this report.

TFG-1 and TFG-2 will be enclosed in insulated cargo-type shipping containers. The shipping container will comply with Uniform Building Code (UBC) requirements and/or DOE general design criteria 6430.1A, whichever is more stringent. The foundation for the shipping container will consist of either asphaltic concrete paving, or 6 in. of base rock, or grading of the existing surface to support the full weight of the shipping container. For maintenance access, there will be a roll-up door along the end of the shipping container and a standard doorway on one side.

From the wellheads, ground water will be pumped to TFG-1 and TFG-2 through 1- to 3-in. inside-diameter polyvinyl chloride pipe. Influent piping that cannot be visually monitored will be instrumented with a leak detection system in double-contained pipe. This system will be a Trace Tek 300 Long Line System, manufactured by Raychem Corporation, or equivalent, that is monitored and alarmed at TFG-1 and TFG-2. This system will detect aqueous fluids at any point along the cable's length, alarm the system, and indicate the distance from the treatment facility to the leak. Ground water will then enter a five-micron filtration system to remove suspended particles from the ground water. From the filtration system, ground water will flow to the air stripper. The aeration process will reduce VOCs in the water to concentrations less than or equal to the discharge limit of 5 ppb. The air stripper will be a commercially available Shallow-tray Model No. 2331, or equivalent.

The supply air for aeration will come from a single blower. The air stripper is available with only one size blower that is expected to have an output of approximately 300 cubic feet per minute (cfm) with a pressure of 18 in. water column. The blower is a component of the air stripper package.

Once removed from the water, the VOCs will be exhausted from the air stripper and pass through a single GAC canister, where the VOCs will be adsorbed to the carbon. The GAC will adsorb volatilized VOCs such that no VOCs will be emitted to the atmosphere above the 6 $ppm_{V/V}$ BAAQMD limit. The GAC canister contains 140 lbs of carbon with a 4.5-in. pressure drop at 450 cfm flow. Effluent VOC concentrations from the GAC will be measured by an organic vapor analyzer photoionization detector (PID) or flame ionization detector (FID). GAC will be replaced as needed to remain in compliance with the 6 $ppm_{V/V}$ BAAQMD limit. The GAC will be delivered to the LLNL Hazardous Waste Management Division (HWMD) for regeneration or offsite disposal at a Resource Conservation and Recovery Act (RCRA)-permitted facility.

The sump of the air stripper will contain the level controls for the discharge pump (Plate 2). The level control system will consist of high and low level switches that alternate turning the discharge pump on and off, respectively. If needed for pH control, an alternate level control system will consist of a level-sensing device in the sump which, in a closed-loop feedback system, controls the speed of the stripping tank discharge pump to keep the water level in the tank constant. The water will then be pumped through an ion-exchange canister or chromium reduction unit, if necessary, and then to an approved discharge location.

Should chromium treatment become necessary, a commercially purchased ion-exchange unit with Purolite A-600 or equivalent anion-exchange resin, or a chromium reduction unit or equivalent technology, will be added after the air stripper unit. The ion-exchange canister will be regenerated at another onsite facility as needed.

Treated water pH will be monitored monthly to determine if it exceeds the WDR Order No. 91-091 discharge limit range of 6.5–8.5. If pH adjustment is necessary, carbon dioxide, acid injection, or another method will be used.

3.1.2. Treatability Tests

To assist in the design of the skid-mounted treatment facilities, treatability tests were conducted with ground water from wells MW-464 (TFG Area) and MW-361 (TFD Area). Water from MW-464 was tested to design TFG-1 and TFG-2. Water from MW-361 was used to provide data for designing skid-mounted facilities that may be used anywhere at LLNL. Separate tests treated about 1,000 gal of ground water from these wells using a single shallow-tray air stripper. Six air-to-water ratios were used in batch tests to evaluate the air stripper performance. Test results are shown in Tables 6 and 7.

Table 6. Air stripper treatability test results for MW-464[a].

Air/water flow ratio (cfm/gpm)	Water flow rate (gpm)	TCE	PCE	Chloroform	Carbon tetrachloride
		<-----Concentration (ppb)----->			
0	—	23[b]	9.3[b]	20[b]	9.3[b]
5.75	45	<0.4	<0.4	<0.4	<0.4

[a] Analyses performed by LLNL's onsite laboratory.

[b] Concentrations at a zero air/water flow ratio represent the highest influent concentration reported from all the batch tests using water from this well.

Table 7. Air stripper treatability test results for MW-361[a].

Air/water flow ratio (cfm/gpm)	Water flow rate (gpm)	TCE	PCE	1,2-DCA	1,1-DCE	cis-1,2-DCE
		<-----Concentration (ppb)----->				
0	—	1,552[b]	323[b]	59[b]	75[b]	5.3[b]
5.59	45	14	0.6	17	<0.4	<0.4
9.67	30	1.4	<0.4	3.2	<0.4	<0.4
15.5	20	<0.4	<0.4	<0.4	<0.4	<0.4

[a] Analyses performed by LLNL's onsite laboratory.

[b] Concentrations at a zero air/water flow ratio represent the highest influent concentration reported from all the batch tests using water from this well.

The results of the treatability test using ground water from well MW-464 were used to design TFG-1 and TFG-2. TCE, PCE, carbon tetrachloride, and chloroform concentrations were plotted as a function of the total blower air injected in cubic feet per minute of air per gallon per minute of water (ft^3/gal or cfm/gpm). The results were used to determine the required air/water ratio for treating these constituents to concentrations below the 0.5 ppb detection limit (Fig. 8).

TCE was chosen to determine the air/water ratio because it occurs in the highest concentration in the TFG Area. The analytic detection limit of 0.5 ppb was used as the design criterion to provide a safety factor of ten relative to the 5 ppb discharge limit. The treatability test results indicate that a ratio of about 6 cfm/gpm is sufficient to reduce TCE concentrations below the detection limit of 0.5 ppb (Fig. 8). At an average influent flow rate of 30 gpm, the required air flow rate is 30 gpm multiplied by 6 cfm/gpm, or 180 cfm.

The results of the treatability test using ground water from well MW-361 (TFD Area) were used to determine the minimum skid-mounted system design capable of treating ground water containing VOCs throughout the Livermore Site. TCE, 1,2-dichloroethane (1,2-DCA), and PCE concentrations were plotted as a function of the total blower air injected in ft^3/gal or cfm/gpm. The results were used to determine the required air/water ratio for reducing these constituents to concentrations below the 0.5 ppb detection limit (Fig. 9).

TCE and 1,2-DCA were used to determine the air/water ratio in Figure 9. TCE is the most widespread contaminant of concern at the Livermore Site and has the highest reported concentrations (Thorpe *et al*., 1990). The analytic detection limit of 0.5 ppb was used as the design criterion to provide a safety factor of ten relative to the 5 ppb discharge limit. The treatability test results indicate that a ratio of about 15 cfm/gpm is required to reduce TCE and 1,2-DCA concentrations below the 0.5 ppb detection limit (Fig. 9). At an average influent flow rate of 20 gpm, the required air flow rate is 20 gpm multiplied by 15 cfm/gpm, or 300 cfm.

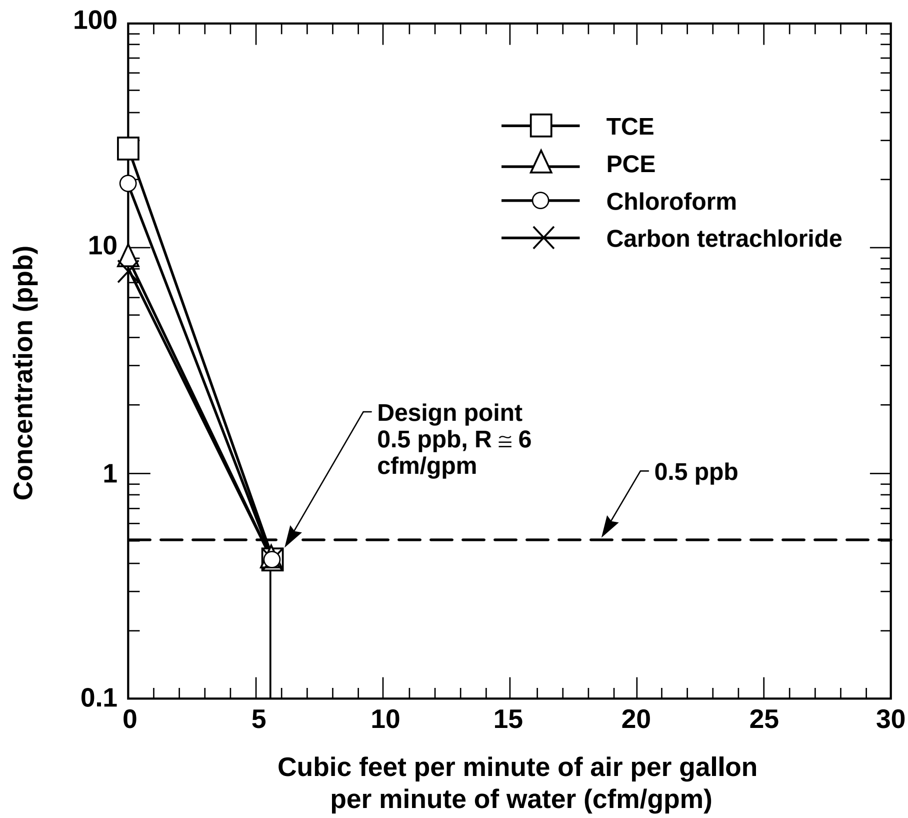
The results from the treatability tests indicate that by varying the ground water flow rate and air-to-water ratio, TFG-1 and TFG-2 will effectively remediate the low VOC concentrations in the TFG Area, as well as higher VOC concentrations at other locations at the Livermore Site based on data from MW-361.

3.1.3. Controls and Safeguards

TFG will be designed to be fail safe; i.e., the failure of any component, energy source (mechanical of electrical), or loss of control signal will cause the system to shut down safely. Commercial systems purchased for TFG-1 and TFG-2 will be provided with built-in safety interlocks, which will be verified independently by LLNL. TFG-1 and TFG-2 will be equipped with an interlock control system (Plate 2). If one of the components listed below malfunctions, the entire system, including the associated extraction well pumps, will automatically shut down. The operator will be notified of a shutdown by a visual alarm. The operator must determine and correct the problem before the system can be manually restarted.

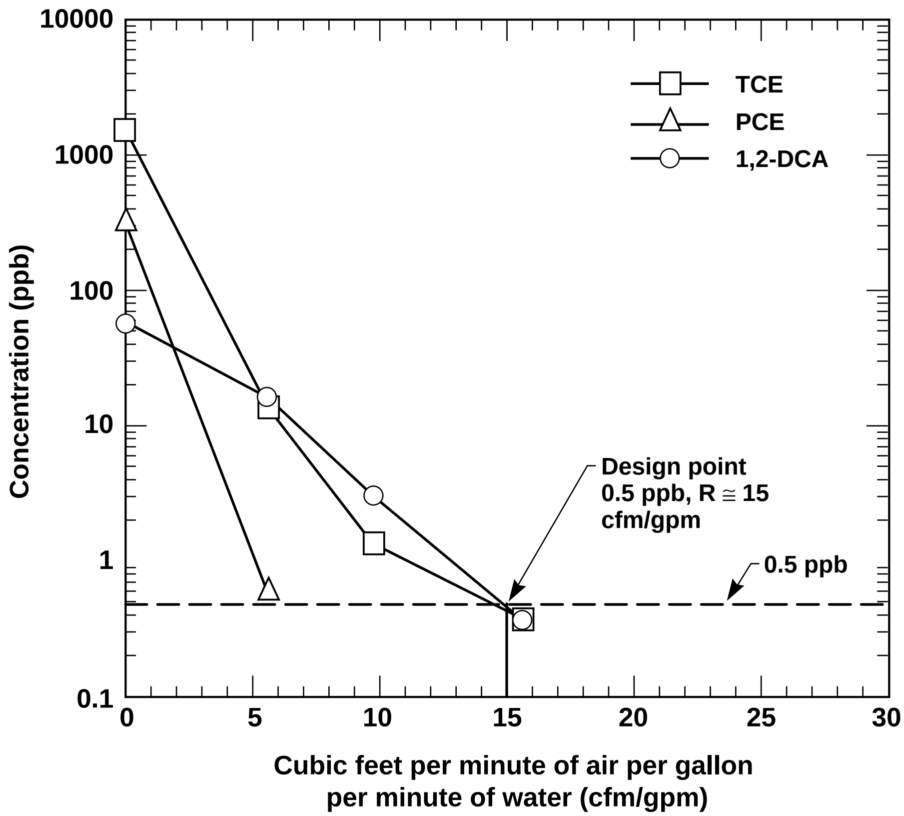
A system shutdown involves de-energizing the following equipment:

- Well pumps.
- Blower.
- Discharge pump.
- Ion-exchange unit, if necessary.
- Chemical injection pumps or carbon dioxide injection, if scale control and/or pH control are operating.



RD5 Fig 08

Figure 8. TFG-1 and TFG-2 airflow design graph using ground water from MW-464.



RD5 Fig 09

Figure 9. General skid-mounted facility airflow design graph using ground water from MW-361.

A system shutdown would be initiated by the following interlocks:

- Low water level in the wells or low flow rate through the facility.
- Low air pressure through the air stripper.
- High air pressure through the air stripper.
- High water flow rate through the facility.
- pH out-of-range, as sensed by final effluent pH monitor (if needed).
- Loss of power to control and instrumentation.
- Leak detected within inaccessible pipelines, if installed.
- High water level in air stripper sump.

In addition, all aboveground pipelines will be visually monitored for leaks on a daily basis. Underground pipelines will be doubly contained with a leak detection system installed inside the outer pipe.

3.2. Discharge of Treated Ground Water

Ground water treated at TFG-1 and TFG-2 will be discharged to a storm drain. If acceptable to the RWQCB, the treated water may be discharged under the existing permit to the LLNL Recharge Basin located south of East Avenue. The treated water may also be used for onsite irrigation or in LLNL cooling towers to help reduce the amount of water imported to LLNL.

As discussed in Section 4.2.1, self-monitoring receiving water samples will be collected from the body of water receiving the discharge. Analyses of receiving water samples will be conducted according to the specifications in WDR Order Nos. 91-091 or 88-075 (Appendix B).

3.3. Construction and Startup Schedules and Cost Estimates

3.3.1. Schedules

Technology evaluations and conceptual designs for TFG-1 and TFG-2 are being conducted by ERD. Following completion of the conceptual design, LLNL Plant Engineering will complete the final design that will be used for construction. Construction of TFG-1 will begin in December 1995 (Table 8) and the facility is scheduled to be operational by April 18, 1996; construction of TFG-2 will begin March 1999 (Table 9) and the facility is scheduled to be operational by August 2, 1999 (Revised Table 5 in Dresen *et al.*, 1993).

Table 8. TFG-1 design and construction schedule.

Item	Start	End
TFG-1 design	5/95	9/95
TFG-1 construction	12/95	3/96
TFG-1 activation	3/96	4/18/96

Table 9. TFG-2 design and construction schedule.

Item	Start	End
TFG-2 design	8/98	12/98
TFG-2 construction	3/99	7/99
TFG-2 activation	7/99	8/2/99

3.3.2. Cost Estimates

The estimated costs for design, construction, and O&M of TFG-1 and TFG-2 are shown in Table 10. The cost associated with TFG-1 and TFG-2 skid construction in Table 10 includes site preparation, design and construction for the initial influent and effluent pipelines, facility power, and power to the wellheads.

The cost associated with the air stripping equipment includes the air stripper, blowers, in-line water filters, effluent GAC, air stripping tank discharge pump and control, and if needed, the pH adjustment metering pump and control.

The cost of the ion-exchange units, if needed, are included in Table 10. The estimated cost includes the commercially purchased ion-exchange unit, which includes all pumps, piping, tanks, and control hardware.

4. Remedial Action Workplan

The Remedial Action Workplan for TFG-1 and TFG-2 includes QA/QC plans and HASPs for construction, operation, and maintenance. Included also are monitoring and reporting programs, requirements for onsite storage and offsite shipment of hazardous waste, and procedures for facility and well closure. As discussed in the RAIP (Dresen *et al.*, 1993), DOE/LLNL have updated the Community Relations Plan (CRP) for the post-ROD period. The Revised CRP was issued in July 1993 (Anderson *et al.*, 1993).

4.1. Quality Assurance/Quality Control and Health and Safety Plans

The QA/QC Plan and the HASP for construction are applicable to all treatment facilities and were presented as Appendices B and C of RD1, respectively (Boegel *et al.*, 1993).

The QA/QC Plans for O&M of TFG-1 and TFG-2 are presented in Appendix C. These plans describe the organizational structure, responsibilities, and authority for O&M QA/QC, and the objectives, quality goals, and QA levels for O&M of TFG-1 and TFG-2. Appendix D contains the HASPs for O&M of TFG-1 and TFG-2. These plans present (1) hazard analyses and control measures and training requirements for TFG-1 and TFG-2 O&M, and (2) emergency safety procedures.

4.2. Monitoring and Reporting

The following sections discuss planned monitoring and reporting for TFG-1 and TFG-2. The programs include self-monitoring required by the RWQCB, ground water quality sampling,

Table 10. TFG-1 and TFG-2 cost summary.

Item	Cost	Annual O&M[a]	53-year cleanup O&M[a]
TFG-1 skid (including design, construction, and process equipment)	$268,116	—	—
Site preparation (including piping, power, and wellhead construction)	235,942	—	—
Ion-exchange units (if needed)	26,812	—	—
Activation cost	42,899	—	—
12% MPC[b]	68,852	—	—
Subtotal	642,621	—	—
TFG Operations & Maintenance:			
Labor:			
ERD personnel[c]	—	$287,635	$9,060,496
HWM[d]	—	6,435	341,055
Plant support	—	32,174	1,705,222
Subtotal	—	*326,244*	*11,106,773*
Materials:			
Extraction wells	—	2,574	136,422
Ion-exchange resin (if needed)	—	3,754	198,962
Pumps	—	257	13,621
Filters	—	3,861	204,633
Carbon housing	—	1,609	85,277
Blower	—	257	13,621
Holding tanks	—	5,148	272,844
pH metering (if needed)	—	5,791	306,923
Miscellaneous piping	—	1,287	68,211
Miscellaneous electronics	—	643	34,079
Sample analyses	—	25,739	1,364,167
HWM[d]	—	142,337	7,543,861
12% MPC[b]	—	6,110	323,851
Subtotal	—	*199,367*	*10,566,472*
16% G&A/LDRD[e] charge	102,819	84,098	3,467,726
TFG-1 Cost[a]	*$745,440*	*$609,709*	*$25,140,971*
TFG-2 Cost[f]	*$815,295*	*$683,206*	*$28,171,525*
Total Cost	$1,560,735	$1,292,915	$53,312,496

[a] Estimated TFG-1 cost is in Fiscal Year 1996 dollars.

[b] Material Procurement Charge.

[c] ERD personnel labor estimates include hydrogeologist, chemist, engineer, technician, and analyst time to meet the requirements in the ROD and milestones in the RAIP. The 53-year cleanup cost reflects time for these staffs to maintain and improve treatment systems, effectively manage the wellfield as conditions change over the life of the cleanup, and evaluate and potentially implement new cleanup technologies as they are developed in the future. The estimated cost for ERD personnel is based on a constant level of effort for the first 5 years of the cleanup, about 83% of that effort for years 6 through 10, about 67% of that effort for years 11 through 15, and half the initial effort for years 16 through 53.

[d] LLNL Hazardous Waste Management.

[e] General and Administrative/Laboratory Directed Research and Development cost.

[f] Estimated TFG-2 cost is in Fiscal Year 1999 dollars and is adjusted from TFG-1 cost to include inflation and variations in piping to the extraction wells.

capture zone monitoring, preliminary criteria for determining when remediation is complete, and requirements for system closeout.

QA/QC procedures for collection, analysis, and documentation of influent and effluent ground water samples are included in the LLNL Quality Assurance Project Plan (Rice, 1989), which was prepared according to EPA guidance and was approved by EPA. In addition, the procedures for collection, analysis, and documentation of water samples are described in LLNL Standard Operating Procedures (SOPs) (Rice *et al.*, 1990) Nos.: 2.6, Sampling for Volatile Organic Compounds; 4.1, General Instructions for Field Personnel; 4.2, Sample Control and Documentation; 4.3, Sample Containers and Preservation; 4.4, Guide to Handling, Packaging, and Shipping of Samples; 4.6, QA/QC Requirements for Data Generated by Analytical Laboratories; and 4.8, Calibration and Maintenance of Field Instruments Used in Measuring Parameters of Surface and Ground Water and Soils. The procedures for sample collection at TFG-1 and TFG-2 are presented in Appendix E.

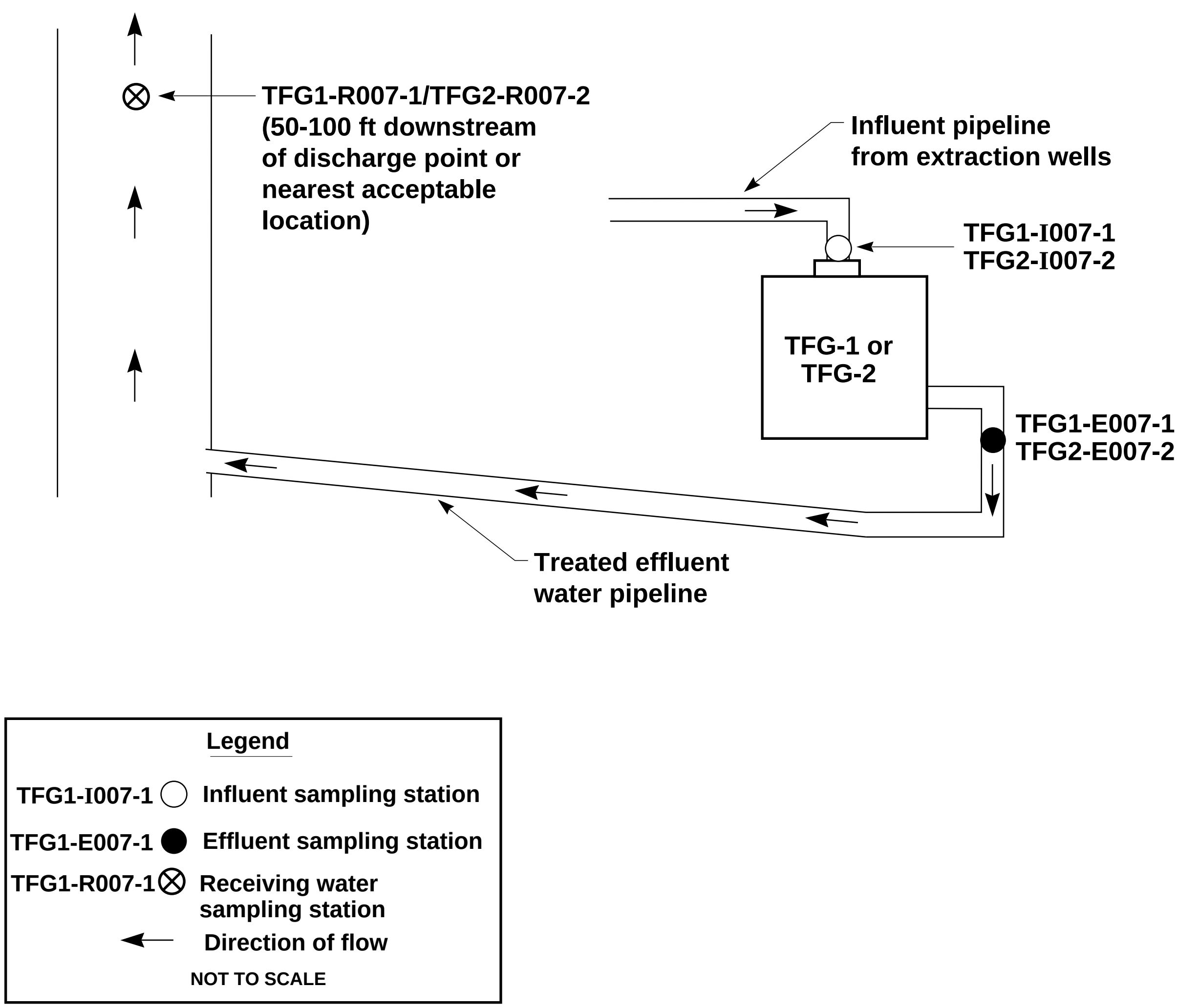
A Draft Compliance Monitoring Plan is scheduled for issuance by August 30, 1995, which will describe the data types and interpretive methods to be used for the duration of the cleanup. Until then, DOE/LLNL will prepare ground water contour and capture zone maps, and report flow, concentrations, and mass removal for each operating extraction well on a quarterly basis. This information will be included in the corresponding *LLNL Livermore Site Ground Water Project Monthly Progress Report* until the Compliance Monitoring Plan is final. At that time, reporting frequency and mechanism may change.

4.2.1. Treatment Facility Self-Monitoring Programs

The TFG-1 and TFG-2 self-monitoring programs will satisfy the requirements of RWQCB WDR Order No. 91-091 (NPDES Permit No. CA 0029289) for discharge to the storm sewer, or if acceptable to the RWQCB, WDR Order No. 88-075 for discharge to the Recharge Basin (Appendix B). Water samples will be collected at TFG-1 and TFG-2 sampling stations (Fig. 10) prior to discharge to the storm sewer, according to the schedule presented in Table 11. Water discharged to the Recharge Basin would be sampled according to the schedule presented in Table 12; Recharge Basin sample locations are shown on Figure 11. Results of TFG-1 and TFG-2 self-monitoring activities will be reported in the *LLNL Livermore Site Ground Water Project Monthly Progress Reports*.

TFG-1 and TFG-2 influent samples, TFG1-I007-1 and TFG2-I007-2, respectively, will be collected immediately prior to treatment. TFG-1 and TFG-2 effluent samples TFG1-E007-1 and TFG2-E007-2, respectively, will be collected following treatment and prior to discharge (Fig. 10). Receiving water samples will be collected from the body of water receiving the discharge.

A PID or FID will be used to determine if any residual compounds of concern remain in the air effluent stream at both TFG-1 and TFG-2 per BAAQMD requirements. The PID uses ultraviolet light to ionize a vapor sample and measure the organic constituents within the vapor. The PIDs used at LLNL are organic vapor meters equipped with 10.0-electron volt lamps and detect double- and triple-bonded molecules. The FID uses the same principle as the photoionization detector, but a flame is used to ionize the vapor sample. LLNL uses Foxboro/Century organic vapor analyzers equipped with FIDs. These instruments can detect



RD5 Fig 10

Figure 10. Schematic diagram of TFG-1 and TFG-2 NPDES self-monitoring program sampling stations.

Table 11. WDR Order No. 91-091 self-monitoring sampling schedule.

Sample location[a]	*Influent*[a] TFG1-I007-1 TFG2-I007-2	*Effluent*[a] TFG1-E007-1 TFG2-E007-2	*Receiving water*[a] TFG1-R007-1 TFG2-R007-2	Land observations[b]
Frequency		**Analysis**		
Daily	Flow rate	Flow rate	Flow rate	—
Weekly	—	EPA 601[c] Hexavalent chromium[d]	—	Perform
Monthly	EPA 601[c] pH	Temperature pH	EPA 601[c] Temperature pH	Complete report
Quarterly	Chlorides	Chlorides Fish toxicity[e] Turbidity[f]	Chlorides	
Semiannually	Metals[g]	Metals[g]	Metals[g] Fish toxicity[e] Turbidity[f]	—
Annually	EPA 624[h,i] EPA 625[k]	EPA 624[h,i] EPA 625[k] Gross alpha and beta particles, and tritium	EPA 602[j] EPA 625[k] Gross alpha and beta particles, and tritium	—

RWQCB specifications:

- Sampling of receiving water should be coincident with influent and effluent water sampling.
- If any instantaneous maximum limit is exceeded, the sampling frequency shall be increased to daily until two samples collected on consecutive days comply with the instantaneous maximum.

[a] Sample locations are shown in Figure 10.

[b] As required by RWQCB NPDES Permit No. CA 0029289, WDR Order No. 91-091.

[c] EPA 601 = EPA Method 601; analysis for volatile halocarbons by gas chromatography.

[d] Weekly monitoring for hexavalent chromium will be conducted for the first three months of initial operation. At that point, the performance of the treatment systems will be reviewed, and the monitoring schedule will be re-evaluated.

[e] Fish toxicity, survival rate for 96 hours in undiluted waste.

[f] Jackson turbidity units.

[g] Priority Pollutant Metals:

antimony	chromium (total)	mercury	silver
arsenic	copper	nickel	thallium
beryllium	lead	selenium	zinc
cadmium			

PLUS: boron, chromium (VI), iron, manganese, and cyanide.

[h] When schedule calls for coincident EPA Method 601 and 624 analyses, only EPA 624 is conducted.

[i] EPA 624 = EPA Method 624; analysis for volatile organic compounds by gas chromatography/mass spectrometry.

[j] EPA 602 = EPA Method 602; analysis for volatile aromatic hydrocarbons by gas chromatography.

[k] EPA 625 = EPA Method 625; analysis for semivolatile organic compounds by gas chromatography/mass spectrometry.

Table 12. WDR Order No. 88-075 self-monitoring sampling schedule.

Sample location[a]	*Influent*[a] TFG1-I007-1 TFG2-I007-2	*Effluent*[a] TFG1-E007-1 TFG2-E007-2	*Recharge Basin*[a] TFA-C1E/C1W and TFA-C2E/C2W	Land observations[b]
Frequency[b]		**Analysis**		
Daily	Flow rate	Flow rate	—	—
Weekly	—	EPA 601[c]	—	Perform
Monthly	EPA 601[c] pH	Temperature pH	—	Complete report
Quarterly	Chlorides	Chlorides Fish toxicity[d] Turbidity[e]	Chlorides EPA 601[c]	—
Semiannually	Metals[f]	Metals[f]	Metals[f] Gross alpha and beta particles, tritium Fish toxicity[d]	—
Annually	EPA 624[g,h] EPA 625[j]	EPA 624[g,h] EPA 625[j] Gross alpha and beta particles, tritium	EPA 602[i] EPA 625[j]	—

RWQCB specifications:

- Sampling of TFA-C1E/C1W and TFA-C2E/C2W should be coincident with TFG1-I007-1/TFG2-I007-2 and TFG1-E007-1/TFG2-E007-2 sampling.
- If any instantaneous maximum limit is exceeded, the sampling frequency will be increased to daily until two samples collected on consecutive days comply with the instantaneous maximum.

[a] Sample locations shown in Figures 10 and 11.

[b] As required by RWQCB WDR Order No. 88-075.

[c] EPA 601 = EPA Method 601; analysis for volatile halocarbons by gas chromatography.

[d] Fish toxicity, survival rate for 96 hours in undiluted waste.

[e] Jackson turbidity units.

[f] Priority Pollutant Metals:

antimony	chromium (total) mercury	silver	
arsenic	copper	nickel	thallium
beryllium	lead	selenium	zinc
cadmium			

PLUS: boron, chromium (VI), iron, manganese, and cyanide.

[g] When schedule calls for coincident EPA Method 601 and 624 analyses, only EPA 624 is conducted.

[h] EPA 624 = EPA Method 624; analysis for volatile organic compounds by gas chromatography/mass spectrometry.

[i] EPA 602 = EPA Method 602; analysis for volatile aromatic hydrocarbons by gas chromatography.

[j] EPA 625 = EPA Method 625; analysis for semivolatile organic compounds by gas chromatography/mass spectrometry.

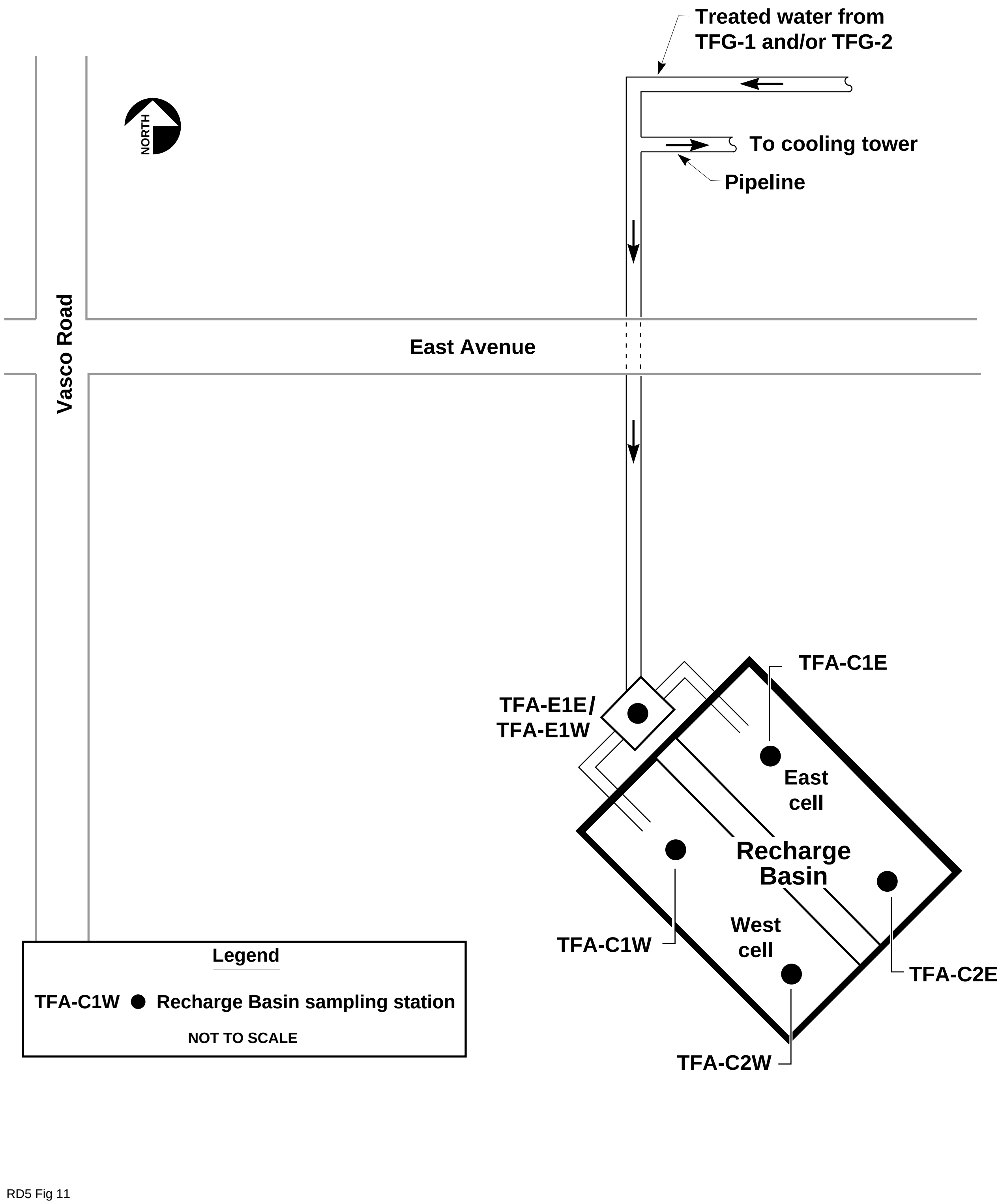


Figure 11. Locations of Recharge Basin self-monitoring program sampling stations.

compounds within a concentration range of 1 to 100,000 $ppm_{V/V}$. The detection limit for these instruments is about 1 to 2 $ppm_{V/V}$, sufficiently low to ensure compliance with the 6 $ppm_{V/V}$ air discharge limits.

4.2.2. Ground Water Monitoring Sampling Schedule

Ground water samples will be collected from existing monitor wells and piezometers in the vicinity of TFG-1 and TFG-2, according to the schedule shown in Table 13. Ground water samples will also be collected quarterly for six consecutive quarters from new monitor wells and piezometers to monitor the progress of the cleanup. The subsequent sampling schedule may be changed quarterly according to the procedures detailed in McConachie (1993), as the distribution of contaminants in ground water changes.

Analytical results of monthly self-monitoring influent water samples collected at TFG-1 and TFG-2 will be used to evaluate remediation effectiveness and calculate VOC removal rates. The TFG-1 and TFG-2 influent samples will be analyzed for VOCs, semivolatiles, chlorides, and metals, according to the schedules presented in Tables 11 and 12.

Water levels in all monitor wells and piezometers will continue to be monitored on a monthly basis either manually or using pressure transducers and data loggers. Depth-to-water and pumping rates in extraction wells will be measured using pressure transducers and mechanical or electronic flow meters. The data will be automatically recorded using data loggers. These data will be used to estimate actual hydraulic capture zones and areas of little or no ground water movement. Based on hydraulic data, pumping locations and rates may be varied, and/or new extraction wells may be installed, to ensure complete hydraulic capture of the VOC plumes and the most expeditious remediation that funding allows.

Prior to issuing the Compliance Monitoring Plan, treatment system monitoring, chemical analytic results, and ground water elevation contour and capture zone maps will be presented on a quarterly basis in the corresponding *LLNL Livermore Site Ground Water Project Monthly Progress Reports*. Once the Compliance Monitoring Plan is final, reporting frequency and mechanism may change.

4.2.3. Extraction Well Pumping Strategy

Current simulations of long-term pumping and contaminant transport suggest that at least 50 years of sustained ground water pumping may be required to achieve remediation goals. Modeling results are summarized in Tompson (1990), Tompson *et al.* (1991), and Tompson *et al.* (in preparation). Extraction wells will initially be pumped at the maximum sustainable flow rates to achieve both rapid mass removal and the largest hydraulic capture zones possible. After steady state is achieved, monitoring data will be used to refine and update the ground water model. As these results and new data are interpreted, the wellfield configuration and pumping rates will likely be modified to optimize mass removal rates, maximize treatment and minimize dilution of contaminants, ensure hydraulic capture in all zones exceeding cleanup standards, and eliminate stagnation zones. Well condition will be periodically addressed by evaluating pumping rates, drawdown and water clarity. As required, extraction wells, monitor wells, and piezometers will be rehabilitated or replaced. These activities will be reported in the LLNL Monthly Progress Reports, as appropriate.

Table 13. Ground water sampling schedule for monitor wells and piezometers in the vicinity of TFG-1 and TFG-2 extraction wells.

Well name	Analyses	Sampling frequency	Planned months of sampling
MW-111	601	A	December
MW-146	601	A	September
MW-147	601, tritium	A	September
MW-148	601, tritium, Cr(VI)	A	September
MW-202[a]	601	A	April
MW-253	601	Q	January, April, July, October
MW-307	601	S	January, July
MW-464	601	S	April, October
	Cr(VI)	A	October
MW-551	601	S	January, July
MW-560	601	A[b]	April
MW-618	601	A	June
TW-11	601	S	January, July
TW-11A	601	S	January, July

[a] The well is currently dry.

[b] If this well is used as an extraction well prior to issuing the Compliance Monitoring Plan, the sampling frequency will be increased to quarterly.

A = Annual.

S = Semiannual.

Q = Quarterly.

Cr(VI) = Hexavalent chromium.

601 = EPA Method 601 for halogenated VOCs.

Note: New piezometers and wells will be sampled quarterly for the first six consecutive quarters. Subsequent monitoring frequency will be based on VOC concentrations and the location within or relative to the plume.

Based on the results of LLNL pilot studies and data from other sites, the VOC concentrations in ground water are expected to decrease rapidly at first, then decrease very slowly or stabilize. Estimates of VOC removal over time at TFG-1 and TFG-2 are shown in Figures 12 and 13, respectively. The VOC removal rates were estimated using results from the two-dimensional, finite-element ground water flow and transport model CFEST (Tompson *et al.*, 1991; Tompson *et al.*, in preparation). The estimated volume of VOCs removed was calculated using a weighted average VOC density. Actual VOC removal rates will depend on the VOC concentrations in extracted ground water and long-term well yields.

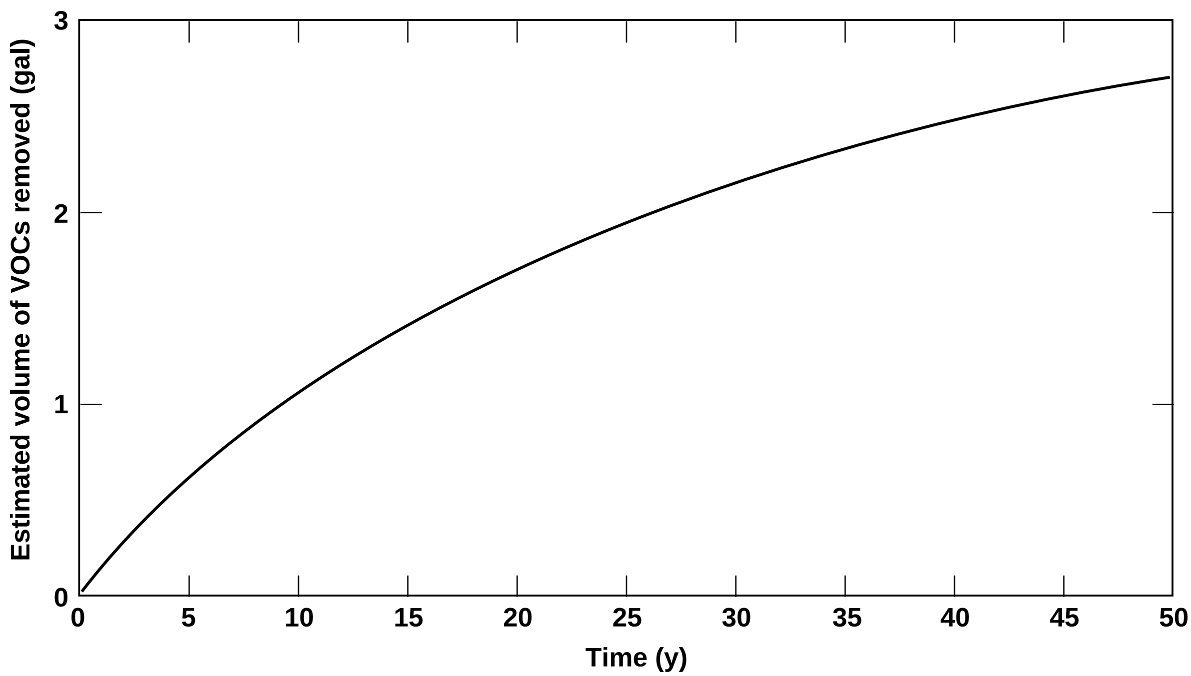
Several methods may be used to maximize VOC removal rates, including cyclical pumping and reinjection of treated ground water, which may include the injection of heat, surfactants, microbes, or nutrients (Isherwood *et al*., 1992). Laboratory and field studies may be conducted to evaluate the effectiveness of the methods used to enhance contaminant mobility and mass removal. Any method used to maximize mass removal rates would comply with State Water Resources Control Board Resolution No. 68-16, an ARAR for the Livermore Site, and would be implemented with regulatory approval.

In one approach, some LLNL extraction wells (i.e., those in former source areas with VOCs in the shallowest ground water) may be periodically shut off and the water levels allowed to recover. During the pump-off cycles, VOCs will desorb into the ground water from the sediments that were dewatered near the pumping wells. Cycling the pumps may increase VOC removal rates near former source areas, where most of the VOCs occur in the shallower water-bearing sediments. Different pump-on and pump-off cycles may be evaluated to determine the optimum periods of pumping and nonpumping to maximize VOC mass removal rates.

In another approach, reinjection of treated ground water may be used to increase the rate of flushing in regions of high VOC concentrations and to mitigate excessive dewatering that may result from ground water extraction. Reinjection of treated water in selected locations will enhance desorption of contaminants and increase the flushing rate in regions of slow ground water flow. The reinjection process may be enhanced by other means to increase the cleanup rate. If the water is heated prior to reinjection, VOCs will have a greater tendency to desorb from the sediments into the ground water than if the water is not heated. Similar benefits may arise if the reinjected water contains surfactants, which are compounds that increase the tendency for VOCs to dissolve in ground water. Such surfactants may be manufactured or microbially produced. If these or other methods are evaluated and shown to be beneficial and cost-effective, they will be implemented with regulatory agency approval. As discussed in the RAIP, all injection well locations will be within the capture area of an extraction well because the reinjected water may contain up to 5 ppb total VOCs.

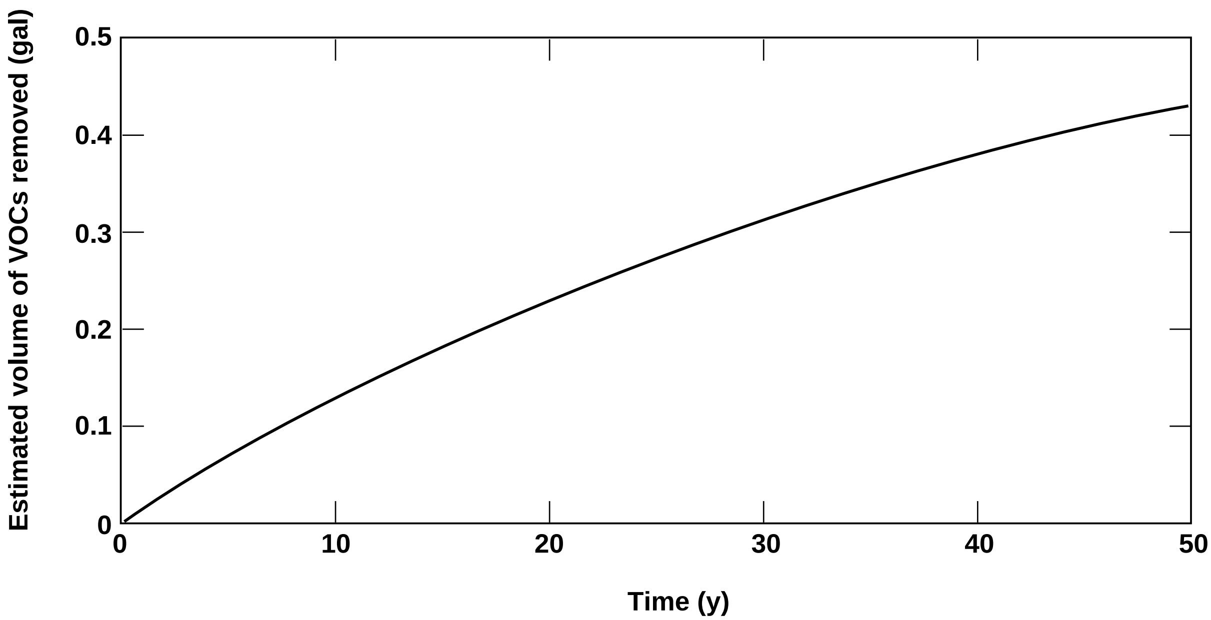
4.3. Requirements for Onsite Storage and Offsite Shipment of Hazardous Waste

Particulate filters and GAC containing sorbed VOCs will be shipped offsite for regeneration or disposal, and will be managed as hazardous waste, if appropriate. GAC will be replaced as needed to remain in compliance with the BAAQMD air discharge limit of 6 $ppm_{V/V}$. LLNL can temporarily store hazardous waste onsite for up to 90 days. Shipment and disposal are in accordance with Department of Transportation (DOT) 49 Code of Federal Regulations (CFR)



RD5 Fig 12

Figure 12. Cumulative volume of VOCs that may be removed from ground water by TFG-1 over time.



RD5 Fig 13

Figure 13. Cumulative volume of VOCs that may be removed from ground water by TFG-2 over time.

and EPA 40 CFR, respectively. Additionally, waste shipments are made according to California Code of Regulations, Title 22 requirements. The spent GAC will be packaged and labeled for shipment by LLNL's HWMD. HWMD operates under interim status and has submitted a RCRA Part B permit application to the DTSC. (California is a fully RCRA-authorized State.) Once packaged, the GAC will be shipped to one of several RCRA-permitted facilities for regeneration or disposal.

4.4. Requirements for Closeout

Decisions regarding when extraction should cease at specific wells and when a particular treatment facility and its influent extraction wells should be decommissioned will be discussed in the forthcoming Compliance Monitoring Plan. As specified in the ROD, sitewide cleanup will be complete when ground water samples from the plume demonstrate that negotiated ARARs are achieved.

VOC concentrations may rise in wells after extraction ceases due to slow desorption from fine-grained sediments. Therefore, contaminant concentrations will be monitored quarterly for 2 years after pumping ceases. If concentrations rise above cleanup levels, extraction will resume at the appropriate wells until cleanup levels are again achieved. Several pumping cycle iterations may be required to achieve the remediation standards. Cleanup will be considered complete when contaminant concentrations remain below the remediation standards for 2 years. Cleanup completion will be determined in conjunction with the regulatory agencies.

After concurrence with the regulatory agencies that cleanup is complete, most of the LLNL extraction wells and piezometers will be sealed and abandoned. All wells screened in more than one water-bearing zone will be sealed to prevent potential vertical migration of compounds of concern. Wells will be sealed by pressure grouting using a grout mixture of 98% Portland cement and 2% bentonite powder by weight, as described in LLNL SOP 1.7 (Rice *et al.*, 1990). Cement grout should extend to a depth of 2 to 3 ft below grade. Wellhead abandonment will include removal of any protective covers, instruments, concrete pads, etc., and the upper 2 to 3 ft will be filled with low-permeability soil to restore grade. A minimal monitoring network, consisting of perhaps 10 to 20% of the existing wells, will remain in place for general ground water quality monitoring. Most of these monitor wells will be located at former downgradient plume margins, site boundaries, and in former source areas.

After remediation is complete, TFG-1 and TFG-2 and their influent and discharge piping will be decontaminated, dismantled, and salvaged, or used at other locations at the Livermore Site. The portions of the process equipment and piping that contact ground water will not contain hazardous VOC concentrations because the equipment will have been thoroughly flushed with ground water containing VOC concentrations below MCLs. Any wash water containing hazardous materials will be collected, sampled, and disposed at one of several RCRA-permitted facilities. GAC with sorbed VOCs will be disposed according to the specifications described in Section 4.3 "Requirements for Onsite Storage and Offsite Shipment of Hazardous Waste."

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U.S. Environmental Protection Agency (EPA) (1989), *Interim Final Guidance on Preparing Superfund Decision Documents: The Proposed Plan, The Record of Decision, Explanation of Significant Difference, and The Record of Decision Amendment*; Office of Solid Waste and Emergency Response (OSWER) Directive 9335.3-02.

5.2. References for LLNL Facilities Standards, Specifications, and Guide Documents

5.2.1. General

Designs, construction drawings, and specifications will conform to and comply with the applicable requirements of the latest adopted edition of the references listed herein, which will be considered minimum requirements.

5.2.2. Regulations

<u>U.S. Department of Energy (DOE)</u>

DOE 5480.7A Fire Protection Program

DOE 6430.1A General Design Criteria

<u>Code of Federal Regulations (CFR)</u>

10 CFR 435	Energy Conservation Standards
29 CFR 1910	Occupational Safety and Health Standards (OSHA)
29 CFR 1910.7	Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)
47 CFR 15	Telecommunication (FCC Rules, Part 15)

<u>State of California Department of Labor (DOL)</u>

DOL Labor Code	Division 5—Safety in Employment Chapter 9—Miscellaneous Labor Provisions

<u>California Code of Regulations (CCR)</u>

CCR Title 8	Industrial Relations; Chapter 4, Subchapter 6
CCR Title 20	Public Utilities; Chapter 53—Energy Conservation in New Building Construction

<u>University of California, Lawrence Livermore National Laboratory (UCRL)</u>

UCRL 15910	Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards
UCRL 15714	Suspended Ceiling System Survey and Seismic Bracing Recommendations

5.2.3. Codes

<u>American Concrete Institute (ACI)</u>

ACI 318	Building Code Requirements for Reinforced Concrete

<u>American Institute of Steel Construction (AISC)</u>

AISC	Steel Construction Manual (Allowable Stress Design)

<u>American National Standards Institute (ANSI)</u>

ANSI A58.1	Building Code Requirements for Minimum Design Loads for Buildings and Other Structures

American Welding Society (AWS)

AWS D 1.1 Structural Welding Code—Steel

International Conference of Building Officials (ICBO)

ICBO UBC Uniform Building Code

ICBO UMC Uniform Mechanical Code

ICBO UPC Uniform Plumbing Code

National Fire Protection Association (NFPA)

NFPA 70 National Electrical Code

NFPA 90A Installation of Air Conditioning and Ventilating Conditioning Systems

5.2.4. Standards

American Concrete Institute (ACI)

ACI 347 Recommended Practice for Concrete Form Work

American Society for Testing and Materials (ASTM)

American Water Works Association (AWWA)

Construction Specifications Institute (CSI)

National Electric Manufacturers Association (NEMA)

Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACCNA)

5.2.5. LLNL Manuals and Reports

M-010 LLNL Health and Safety Manual

LLNL Site Development and Facilities Utilization Plan

LLNL Landscape Master Plan and Design Guidelines

6. Acronyms and Abbreviations

1,2-DCA	1,2-dichloroethane
1,1-DCE	1,1-dichloroethylene
1,2-DCE	1,2-dichloroethylene
1,1,1-TCA	1,1,1-trichloroethane
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
amsl	above mean sea level
ANSI	American National Standards Institute
ARAR	Applicable or Relevant and Appropriate Requirement
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
AWWA	American Water Works Association
B-212	Building 212
B-321	Building 321
BAAQMD	Bay Area Air Quality Management District
BACT	Best Available Control Technology
CCR	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	chloroform
CFEST	Coupled Fluid Energy and Solute Transport
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CI	Construction Inspector
CM	Construction Manager
CPR	cardiopulmonary resuscitation
CRP	Community Relations Plan
Cr(VI)	hexavalent chromium
CSI	Construction Specifications Institute
CTET	carbon tetrachloride
DOE	U.S. Department of Energy
DOL	U.S. Department of Labor
DOT	U.S. Department of Transportation
DTSC	California Department of Toxic Substances Control
EE	Electronic Engineering
EPA	U.S. Environmental Protection Agency
ERD	Environmental Restoration Division
ES&H	Environmental Safety & Health
F113	trichlorotrifluoroethane
FFA	Federal Facility Agreement
FID	flame ionization detector
Freon 113	trichlorotrifluoroethane
FS	Feasibility Study
GAC	granular activated carbon
gal	gallon(s)
gpm	gallons per minute
G&A/LDRD	General and Administrative/Laboratory Directed Research and Development
HASP	Health and Safety Plan

HCl hydrochloric acid

hp horsepower

hr hour

HWM Hazardous Waste Management

HWMD Hazardous Waste Management Division

ICBO International Conference of Building Officials

LLNL Lawrence Livermore National Laboratory

LSRSL Livermore Site Restoration Section Leader

MCL Maximum Contaminant Level

ME Mechanical Engineering

M&I materials and items

MPC Material Procurement Charge

M&TE measuring and test equipment

NaCl sodium chloride

NEMA National Electric Manufacturers Association

NEPA National Environmental Policy Act

NFPA National Fire Protection Association

NPDES National Pollution Discharge Elimination System

NQA National Quality Assurance

NRTL Nationally Recognized Testing Laboratory

O&M operations and maintenance

OSHA Occupational Safety and Health Administration

OSWER U.S. EPA Office of Solid Waste and Emergency Response

OTL Operations Team Leader

PCE perchloroethylene

PEPE Plant Engineering Project Engineer

PEPM Plant Engineering Project Manager

P&ID piping and instrument diagram

PID photoionization detector

PO purchase order

ppb parts per billion

ppm parts per million

psi pounds per square inch

QA quality assurance

QAM Quality Assurance Manager

QC quality control

RAIP Remedial Action Implementation Plan

RCRA Resource Conservation and Recovery Act

RD Remedial Design

RE Remediation Engineer

RI Remedial Investigation

ROD Record of Decision

rpm revolutions per minute

RWQCB California Regional Water Quality Control Board

SARA Superfund Amendments and Reauthorization Act

SMACCNA Sheet Metal and Air Conditioning Contractors National Association, Inc.

SOP Standard Operating Procedure

TBI to be installed

TCE trichloroethylene

TD total depth

TFD Treatment Facility D

TFE Treatment Facility E

TFG Treatment Facility G

TFG-1 Treatment Facility G-1

TFG-2 Treatment Facility G-2

UBC Uniform Building Code

UCRL	University of California Radiation Laboratory	**v/v**	volume per volume basis
VOC	volatile organic compound	**WDR**	Waste Discharge Requirement

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Appendix A*

Soil and Ground Water Analytical Results

***NOTICE: This appendix exists only in hard copy. It can be found in ERD Trailer 4302's Library.**

Appendix B*

Waste Discharge Requirement Order Nos. 91-091 and 88-075

***NOTICE: This appendix exists only in hard copy. It can be found in ERD Trailer 4302's Library.**

UCRL-AR-116583

Appendix C

Operations and Maintenance Quality Assurance/Quality Control Plan

Appendix C

Operations and Maintenance Quality Assurance/Quality Control Plan

C-1. Introduction

This QA/QC Plan has been developed in support of the O&M for TFG-1 and TFG-2 ground water remediation at the Livermore Site. This plan was prepared to meet the O&M requirements of TFG-1 and TFG-2 using the American Society of Mechanical Engineers (ASME) National Quality Assurance NQA-1, 1989 Edition, as a guideline.

The purpose of this plan is to define the quality objectives and areas of responsibility in accordance with the requirements of the O&M of TFG-1 and TFG-2.

C-2. Organization

This section documents the organizational structure, functional responsibilities, levels of authority, and lines of communications for those aspects of the O&M of TFG-1 and TFG-2 that affect quality.

Figure C-1 shows the organizational structure for QA activities. The descriptions below generally describe the QA responsibilities of those mainly involved in carrying out the QA program for the O&M of TFG-1 and TFG-2. The LLNL ERD Livermore Site Restoration Section Leader, the Quality Assurance Manager, the Remediation Engineer, and other individuals have the following responsibilities:

- The Livermore Site Restoration Section Leader (LSRSL) issues this QA plan and periodically reviews its implementation. The LSRSL may request an independent review or formal audit of the QA program.

- The Quality Assurance Manager (QAM) is responsible for the development and implementation of the QA plan, establishment and control of the QA document files, coordination with appropriate project personnel to assure compliance within groups over which the quality organization has no administrative control, and development of tracking and reporting systems to provide management visibility of implementation activities and results.

- The Remediation Engineer (RE) is responsible for overseeing facility startup and monitoring its performance and operations.

- The LLNL Plant Engineering Project Manager (PEPM) reports to the ERD LSRSL and RE. The PEPM is Plant Engineering's primary contact with ERD for each assigned project. Working as the project team leader, the PEPM is responsible for achieving the objectives of each specific project within the allocated budget and schedule while meeting the established performance criteria, as well as DOE, LLNL, and regulatory standards.

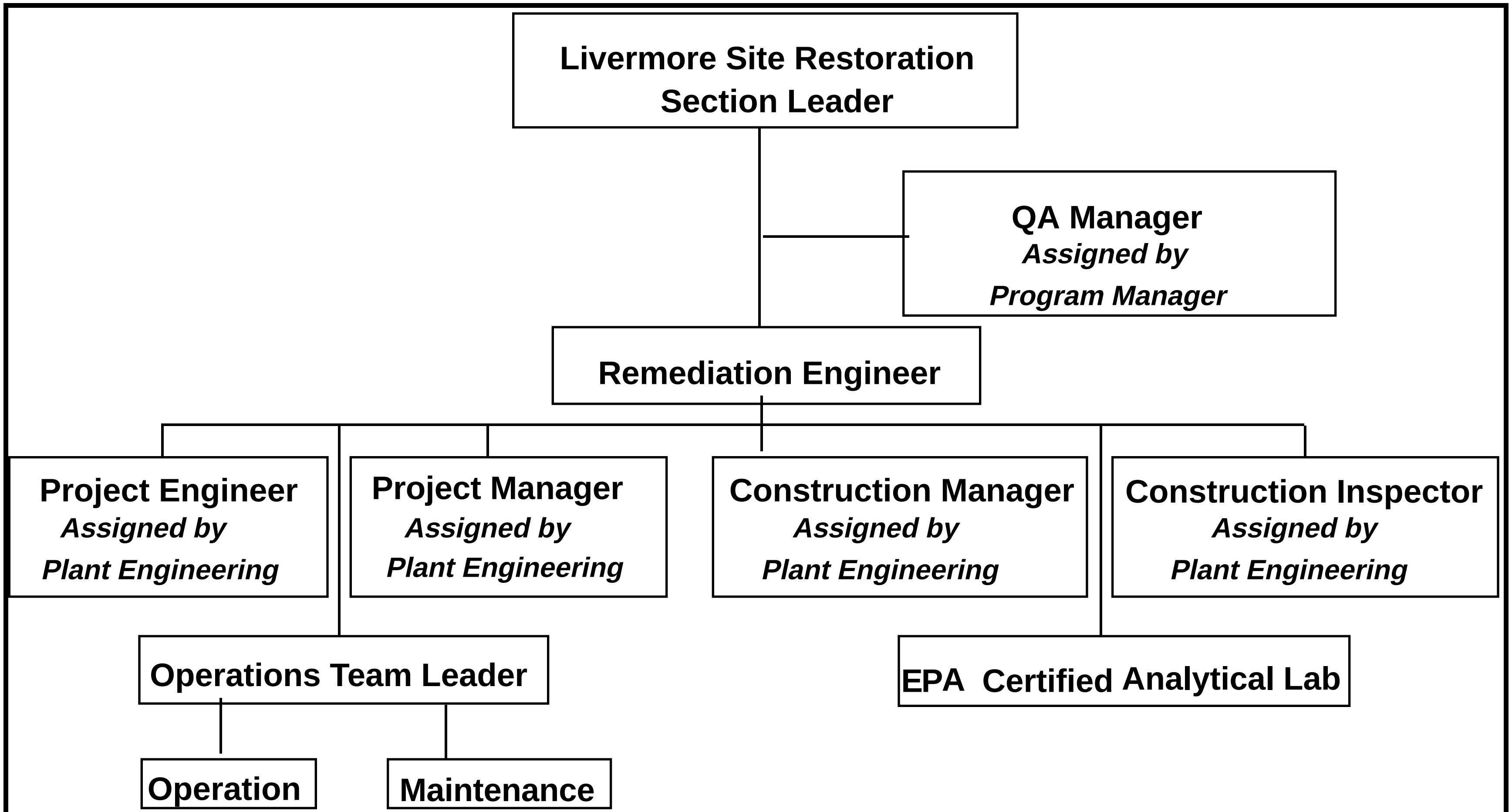

Figure C-1. **Organization chart for operation and maintenance quality assurance/quality control for the B-518 Vapor Treatment Facility.**

- The LLNL Plant Engineering Project Engineer (PEPE) performs the design or monitors and provides direction to engineers/architects with regard to design concepts, schedule, and budget. The PEPE reports operationally to the PEPM.

- The Construction Manager (CM) acts as the single point contact with construction subcontractors, and reports and advises on status, projected cost, and time of completion. Working in conjunction with the Construction Inspector, the CM protects LLNL's interest by assuring that all work is accomplished safely and in conformance with the contract documents. The CM reports operationally to the PEPM.

- The Construction Inspector (CI) will perform all inspector's duties as specified in the "Construction Inspector's Policy and Procedures Manual," the "Construction Manager Manual," and this QA plan. The CI is assigned to specific projects as the LLNL field representative, and provides quality control and status of all construction activities. The CI reports operationally to the CM.

- The Operations Team Leader (OTL) is responsible for the day-to-day maintenance and operation of ground water and soil treatment facilities. This includes scheduling required maintenance and ensuring that the maintenance requested is completed in a timely fashion.

- State Certified Analytical Laboratories using EPA methods are responsible for providing independent chemical analytical results on soil and ground water samples. For TFG-1 and TFG-2, these samples are submitted as part of the self-monitoring program required by LLNL's discharge permit, in addition to operational testing samples collected prior to the official operation of a facility and routine samples taken to evaluate facility performance.

C-3. Quality Assurance Program

This section covers objectives, quality goals, and QA levels. The procedures for the implementation of QA are included in the plan or cited in the list of codes, standards, and specifications (Table C-1).

The objectives of the project supported by this QA plan are to:

- Assure excellence in maintenance services and operations to achieve quality.

- Provide the QA requirements to meet all programmatic and institutional needs.

This QA plan defines the process for providing confidence that these QA objectives will be achieved and that achievement will include due consideration for health, safety, property, and the environment. Table C-2 shows a list of auditable records (including responsible personnel) that are required to document compliance with the requirements of this plan. Table C-3 shows the 18 elements of NQA-1 and their applicability to the Livermore Site Restoration Section activities.

Table C-1. Applicable Codes, Specifications, and Standards for O&M QA for TFG-1 and TFG-2.

"LLNL Procurement Manual," Vol II, Books 1, 2, and Book 4 (Construction Subcontract Manual)
"LLNL Plant Engineering Manual," Volumes 1-5, latest revision
"LLNL Plant Engineering Drafting Manual," PEL-P-02065
"Guidelines For In-House Design Reviews and Project Presentations," Frank Tokarz/ Roger Lake, Plant Engineering Department, Engineering/ Construction Division, LLNL, March 27, 1989 (with May 25, 1989 Rev.)
"Construction Manager Manual, Subcontracted Construction Projects," Plant Engineering Department, LLNL, W. Kleck, January 1989
"Construction Inspector's Policy and Procedures Manual," Plant Engineering Department, LLNL
LLNL "Health and Safety Manual" (M010-May 1991)
Electronics Engineering / Instrument Services Calibration and Certification Manual, LER 87-1007-99
Quality Assurance Plan for Calibration Services, Engineering Measurements and Analysis Section, Engineering Sciences Division, M.E.
LLNL Management Policy Memorandum MPM 02.2 "National Environmental Policy Act (NEPA) Compliance"
DOE Order 4330.4A, Real Property Maintenance Management
Plant Engineering (PE) QA Program Plan
PE QA Manual PEL-P-01010
LLNL Environmental Protection Handbook, issued by the Environmental Protection Department
PE Policy and Operations Manual, PEL-P-01000
PE Specifications, PEL-P-02075
PE Maintenance and Operations QA Plan, M-078-30.6
PE Maintenance and Operations Electric Utilities QA Plan, M-078-30.10
PE Maintenance Services/Operations QA Plan, M-078-30.9
PE Maintenance and Operations Utilities QA Plan, M-078-30.7
PE Maintenance and Operations Maintenance Engineering and Production Control QA Plan, M-078-30.8
PE Maintenance and Operations Electric Utilities QA Plan, M-078-30.10

Table C-2. Required QA records.

QA files	QA record title	Person responsible
TFG1/G2-2-1	Personnel Training Records	QAM
TFG1/G2-3-1	Design Criteria	PEPE
TFG1/G2-3-2	Design Calculations	PEPE
TFG1/G2-3-3a	Design Changes	PEPE
TFG1/G2-3-3b	Specifications	PEPE
TFG1/G2-3-4a	Drawing List	PEPM
TFG1/G2-3-4b	Specifications List	PEPM
TFG1/G2-3-6	NEPA Compliance Documents	PEPM
TFG1/G2-4-1	Design or Construction Purchase Orders	PEPM
TFG1/G2-5	Work Performance and Facility Operations Log	OTL
TFG1/G2-6-1	As-Built Prints	CM
TFG1/G2-7-1	Notice of Completion	CM
TFG1/G2-9-1	Welder Certification	CI
TFG1/G2-9-2	Welding Test Reports	CI
TFG1/G2-9-3	Cemented Joints Test Reports	CI
TFG1/G2-10-1	Inspection Prints	CI
TFG1/G2-10-2	Final Inspection Report	CI
TFG1/G2-10-3	Final Acceptance Report	CI
TFG1/G2-18-1	Audit Requests and Reports	PEPM

Table C-3. Applicability of NQA-1 Elements to the Quality Assurance of TFG-1 and TFG-2.

NQA-1 requirement	Title	Applicable ?
Basic 1	Organization	Y
Supplement S-1	Terms and Definitions	Y
Supplement 1S-1	Supplementary Requirements for Organization	N
Basic 2	Quality Assurance Program	Y
Supplement 2S-1	Supplementary Requirements for the Qualification of Inspection and Test Personnel	N
Supplement 2S-2	Supplementary Requirements for the Qualification of Nondestructive Examination Personnel	N
Supplement 2S-3	Supplementary Requirements for the Qualification of Quality Assurance Program Audit Personnel	N
Supplement 2S-4	Supplementary Requirements for Personnel Indoctrination and Training	N
Basic 3	Design Control	Y
Supplement 3S-1	Supplementary Requirements for Design Control	N
Basic 4	Procurement Document Control	Y
Supplement 4S-1	Supplementary Requirements for Procurement Document Control	N
Basic 5	Instructions, Procedures, and Drawings	Y
Basic 6	Document Control	Y
Supplement 6S-1	Supplementary Requirements for Document Control	N
Basic 7	Control of Purchased Items and Services	Y
Supplement 7S-1	Supplementary Requirements for Control of Purchased Items and Services	N
Basic 8	Identification and Control of Items	Y
Supplement 8S-1	Supplementary Requirements for Identification and Control of Items	N
Basic 9	Control of Processes	Y
Supplement 9S-1	Supplementary Requirements for Control of Processes	N
Basic 10	Inspection	Y
Supplement 10S-1	Supplementary Requirements for Inspection	N
Basic 11	Test Control	Y
Supplement 11S-1	Supplementary Requirements for Test Control	N
Supplement 11S-2	Supplementary Requirements for Computer Program Testing	N
Basic 12	Control of Measuring and Test Equipment	Y

Table C-3. (Continued.)

NQA-1 requirement	Title	Applicable ?
Supplement 12S-1	Supplementary Requirements for Control of Measuring and Test Equipment	N
Basic 13	Handling, Storage, and Shipping	Y
Supplement 13S-1	Supplementary Requirements for Handling, Storage, and Shipping	N
Basic 14	Inspection, Test, and Operating Status	Y
Basic 15	Control of Nonconforming Items	Y
Supplement 15S-1	Supplementary Requirements for the Control of Nonconforming Items	N
Basic 16	Corrective Action	Y
Basic 17	Quality Assurance Records	Y
Supplement 17S-1	Supplementary Requirements for Quality Assurance Records	N
Basic 18	Audits	Y
Supplement 18S-1	Supplementary Requirements for Audits	N

C-4. Operations and Maintenance

C-4.1. Scope

TFG-1 and TFG-2 will operate to treat ground water containing VOCs. Prior to discharge to the storm sewer, the ground water will be treated to meet the requirements specified in California RWQCB WDR Order No. 91-091 (NPDES Permit No. CA 0029289). A table summarizing the effluent discharge requirements is presented in Section A.2 of Order No. 91-091 (Appendix B). If treated water was discharged to the Recharge Basin, it would be treated to meet the requirements specified in WDR Order No. 88-075, if approved by the RWQCB. A table summarizing the effluent discharge requirements is presented in Section B of Order No. 88-075 (Appendix B). Therefore, O&M activities at these facilities shall be controlled by quality procedures.

C-4.2. Operations

The LSRSL is responsible for ensuring the quality of operations at these facilities. The OTLs are responsible for ensuring that all field operations, including maintenance and operations, are performed with the appropriate quality procedures and are completed in a timely fashion. Each treatment facility, per their respective permits, has a required Self-Monitoring Program. This involves collecting water samples for submission to State-certified analytical laboratories for analysis by EPA methods. The results of these analyses are used by LLNL, EPA, RWQCB, and DTSC to monitor the performance of each treatment facility. The OTLs are responsible for ensuring that the technicians are properly trained to collect these samples according to documented procedures.

Each treatment facility has its own set of operating procedures. These procedures, which are being developed, cover the different modes of operation, including startup and shutdown, and are described in the TFG-1 and TFG-2 operating procedure manuals.

Daily operational logs are kept at each facility. These logs record the operating parameters of each system (i.e., temperature, pressure, etc.), the number and type of samples taken, all maintenance performed on the system, and all adjustments made by the operators to the system.

C-4.3. Maintenance

Two types of maintenance are performed at TFG-1 and TFG-2:

- Preventive.
- Corrective.

C-4.3.1. Preventive Maintenance

Preventive maintenance is performed on those components that need routine servicing and are part of systems related to quality. The preventive maintenance schedule is kept at each facility with the operations procedures for TFG-1 and TFG-2. The OTL is responsible for ensuring that the preventive maintenance items are scheduled and completed. Maintenance is performed by the LLNL Plant Operations and/or ERD personnel and follows the QA/QC manuals to ensure quality maintenance is performed.

TFG-1 and TFG-2 are treatment facilities designed to operate on a 24-hr-per-day, 7-day-per-week schedule. To keep these systems in continuous 24-hr operation, a preventive maintenance program is required.

Table C-4 is a tentative schedule of the preventive maintenance for TFG-1 and TFG-2, which includes an ion-exchange system, if necessary.

Table C-4. Preventive Maintenance for TFG-1 and TFG-2.

Action	Frequency/comments
Check all components and pipelines for leaks	Daily. If leaks are found, determine potential effects of leak and take appropriate action
Check prefilter packs 1 and 2	Daily. Pressure drop across filter greater than 2 pounds per square inch (psi) (maximum variation of 5 psi is allowable) indicates a need to change filters
Check air stripper trays for scale build-up (calcium carbonate deposits/iron scale)	Daily. Scale buildup requires system shutdown and lockout of power to the blowers and source well pumps. Remove and clean the trays at B-322, then replace in the air stripper
Sample effluent	Weekly. See WDR Order No. 91-091 (NPDES Permit No. CA 0029289) or WDR Order No. 88-075 (if used)
Clean organic debris from area surrounding the building	Weekly or when necessary. Notify the gardeners (Ext. 3-0495)

Table C-4. (Continued.)

Action	Frequency/Comments
Check for proper operation of eye wash and shower	Weekly. Open eye wash valve. Dust covers should pop off as water flows from eye wash ports, and water should spray up a minimum of 6 in.
Regenerate one of the two resin columns for the ion-exchange unit with 1 to 2 Molar sodium chloride (NaCl) (if an ion-exchange unit is used)	Every 12 days or as necessary based on monitoring. Regeneration is performed at Treatment Facility D (TFD)
Recharge the ion-exchange unit with approximately 500 gal of 1 to 2 molar NaCl (if an ion-exchange unit is used)	Every 12 days or as necessary based on monitoring. Recharging is performed at TFD
Remove waste 1 to 2 molar NaCl and hexavalent chromium (approximately 500 gal) from the ion-exchange unit (if an ion-exchange unit is used)	Every 12 days or as necessary based on monitoring. Performed at TFD
Top off the ion-exchange unit canisters at regular intervals (if an ion-exchange unit is used)	To be determined. Requires approximately 5 ft^3 per year
Shut down and clean out the built-up deposits of calcium bicarbonate or other precipitates in the ion-exchange unit tanks (if an ion-exchange unit is used)	As required
Replenish the hydrochloric acid or the carbon dioxide supply for the pH adjustment (if pH adjustment is used)	As required
Floor maintenance	As required. Contact custodians (Ext. 2-9744) to set up date for stripping and waxing of floors
Service blower motors on air stripper	Annually or as necessary. Motors and pumps to be serviced by Plant Engineering motor shop (Ext. 2-7751), B-511
Test interlock control system	Quarterly
Service well pumps	Annually
Service air stripper variable-speed discharge pump	Annually
Recertify flow sensors	Annually
Operationally verify and/or service level sensors	Annually
Service air compressor	Annually
Inspect miscellaneous hoses, seals, fittings, valves, etc.	Weekly
Replace GAC on air stripping vapor stream	As needed
Replace the entire resin charge for the ion-exchange unit (if an ion-exchange unit is used)	Every 5 years. Requires about 60 ft^3
Service the ion-exchange unit air-actuated valves (if an ion-exchange unit is used)	Every 5 years

C-4.3.2. Corrective Maintenance

Corrective maintenance is performed when a system component fails or is beginning to fail and the quality of facility operations could be compromised if operation continues. Root cause analyses are performed each time a component fails before the corrective maintenance action commences. This is to ensure that the nature of the problem is understood and can be prevented. This root cause analysis is also used to modify the preventive maintenance plan where appropriate. The results of the root cause analyses are documented in the daily facility operations log. As with preventive maintenance, corrective maintenance is performed by the plant operations personnel or ERD in accordance with their maintenance procedures and QA/QC plan.

All corrective maintenance actions and their times of completion are recorded in the facility daily operations log. Once complete, the specific component or system is started up and operated. This ensures that the maintenance is correctly performed and that system quality is maintained. An entry in the facility log is made, indicating that an operational check was made following preventive or corrective maintenance and the performance of the system's new component is noted. If successful, the system is allowed to resume normal operations.

The O&M manuals for TFG-1 and TFG-2, which are currently being developed, will indicate the required spare parts for system components that have relatively high risk of failure or require a long lead time to obtain. These components are to be maintained onsite to prevent extended shutdown of the treatment systems.

C-4.4. Drawing and Specification

The PEPM is responsible for preparing and updating complete drawing and specification lists. The lists shall include all drawings, specifications, and changes for purchase order (PO) contracts, labor only contracts, Job Orders, and Mechanical and Electronic Engineering Department drawings. This list will serve as the index for the QA print files and as the list of prints required in the QA files.

QA records to be filed as required in Table C-2:

(TFG1/G2-3-4a) A current and/or final copy of the drawing list.

(TFG1/G2-3-4b) A current and/or final copy of the specification list.

C-4.5. National Environmental Policy Act (NEPA)

The PEPM is responsible for assuring compliance with NEPA requirements. Completed documentation consists of LLNL Plant Engineering Form 1, NEPA Compliance Project Notification Form, and the NEPA Compliance Environmental Checklist. Memos to and from DOE and Environmental Impact Studies, as applicable, are evidence of NEPA compliance.

QA records to be filed as required in Table C-2:

(TFG1/G2-3-6) NEPA Compliance Documents.

C-5. Procurement

C-5.1. Procurement Contracts

Preparation and approval of PO contracts, when necessary for the purchase of equipment or services needed for maintenance, shall comply with standard LLNL purchasing policies.

QA records to be filed as required in Table C-2:

(TFG1/G2-4-1) Copy of all material and equipment POs over $5,000.

C-5.2. Documents

The approval and control of procurement documents shall conform to LLNL Procurement Manual, Vol. II, Books 1, 2, and 4. The control and approval of maintenance construction drawings shall conform to LLNL Plant Engineering Drafting Manual, PEL-P-02065. Control, format, and approvals of specifications shall conform to Plant Engineering Standard PEL-P-02075 Specifications.

All drawings shall be approved for maintenance construction and have all applicable approval signatures before the bidding process, or, for LLNL construction, before the estimate process. Approvals of major changes to instructions, drawings, and specifications shall be the same as for the original issue.

Minor technical design changes made in the field shall be approved by the CM and the CI on the inspection print, and on the as-built drawings.

QA records to be filed (as required in Table C-2):

(TFG1/G2-6-1) One set of as-built prints for each project.

C-5.3. Control of Purchased Items and Services

Purchased items and services shall be controlled in accordance with standard LLNL Purchasing Policies. A Notice of Completion shall be prepared with all required LLNL signature approvals, and sent to the LLNL Procurement Department before contract close-out.

QA records to be filed (as required in Table C-2):

(TFG1/G2-7-1) Copy of the Notice of Completion for each project.

C-5.4. Handling, Storage, and Shipping

Items and materials shipped to LLNL shall be packaged, shipped, and stored according to instructions on drawings, specifications, contracts, and POs. The RE or OTL will perform a receiving inspection and/or the CI shall inspect incoming items and materials to identify any damage that may have occurred during shipping and storage.

Handling equipment, such as fork lifts and cranes, shall be operated, maintained, and tested in compliance with DOE and California State regulations. When LLNL equipment is used, compliance with the LLNL Health and Safety Manual is required.

Inspection reports are initiated and maintained per the CI's Policy and Procedures Manual. No additional QA records are required for the QA files.

C-5.5. Control of Nonconforming Items

The CI and CM shall maintain cognizance of salvage (rejected or damaged) materials and items (M&I), and arrange for segregation and prompt disposition of LLNL-supplied rejected M&I. The construction subcontractor shall be notified to immediately remove any rejected subcontractor-supplied M&I from LLNL. Any nonconformance that cannot be immediately corrected and verified by the CI shall be documented on a Deficiency Notice or punch list as applicable. Nonconformances to be dispositioned as “use as is” or “repair” (as opposed to rework) must be recorded on a Deficiency Report, approved and signed by the CM.

Inspection reports are initiated and maintained per the CI’s Policy and Procedures Manual. No additional QA records are required for the QA files.

C-6. Maintenance Support

C-6.1. Identification and Control of Items

Material delivered to the job site is inspected to verify compliance with the approved submittals to assure that only correct and accepted items are used or installed.

The CM will request identification and inspection of items arriving at the construction site, when required. Acceptance of M&I not in conformance with requirements shall be approved by the LSRSL and PEPE, and shall comply with the LLNL Procurement Manual.

Inspection reports are initiated and maintained per the CI’s Policy and Procedures Manual. No additional QA records are required for the QA files.

C-6.2. Inspection, Test, and Operating Status

The CI and CM shall maintain cognizance of incoming and stored M&I, and inspect or test them for conformance to requirements. When the CI or CM is concerned with maintaining identification of the status of a shipment of critical M&I, they shall tag them to ensure that untested or rejected items are not inadvertently used.

Lockout tags shall be tied on electrical equipment, lifts and hoists, valves, etc., where such items are unsafe to use, are uncertified, or to protect personnel working on the system.

Inspection reports are initiated and maintained per the CI’s Policy and Procedures Manual. No additional QA records are required for the QA files.

C-6.3. Control of Processes

Procedures for welding, bonding, and other processes shall be called out in specifications or drawings, as required.

When required in construction specifications, bonded joints, welding tests, and inspections, welder certifications shall be verified by the CM and the CI, as required.

QA records to be filed (as required in Table C-2):

(TFG1/G2-9-1) Welder certifications.

(TFG1/G2-9-2) Welding test reports.

(TFG1/G2-9-3) Cemented joints test reports.

C-6.4. Inspection

All maintenance work, and LLNL acceptances within the scope of this QA plan, including PO contract and labor only contract, are subjected to inspection. Work shall be inspected and documented according to the "Construction Inspector's Policy and Procedures Manual" and the "Construction Manager Manual." The inspection team shall delay progress payments to the subcontractor if the work is not in place, or is not up to contract quality.

During construction of modifications, the CI shall maintain a set of as-built marked prints to compare with the subcontractor's prints, and shall review and approve the subcontractor's prints.

After construction, the CI shall verify the accuracy of the as-built drawings in accordance with the CI's policy and procedures manual. The CI and PEPM shall indicate approval of the subcontractors marked up print by signing the as-built drawing.

QA records to be filed (as required in Table C-2):

(TFG1/G2-10-1) All inspection prints, with copies of field memos, change orders, calculations, and sketches attached.

(TFG1/G2-10-2) Final inspection report per Construction Manager Manual.

(TFG1/G2-10-3) Final acceptance report per Construction Manager Manual.

C-6.5. Control of Measuring and Test Equipment

Certified testing laboratory subcontractors shall periodically calibrate measuring and test equipment used for LLNL work according to the requirements in the contract and according to Federal and State codes.

C-7. Activation of Measuring and Testing Equipment

All measuring and test equipment (M&TE) used in acceptance testing of electronic, monitoring, and interlocks systems and items shall be calibrated in accordance with the applicable LLNL calibration manual or plan. The individual conducting the test shall be responsible for assuring that all test equipment is calibrated and within its certification period.

The two major calibration laboratories at LLNL are the Engineering Measurements & Analysis Section, Mechanical Engineering (ME), and the Instrument Services Group, Engineering Services Division, Electronic Engineering (EE). The ME facility typically calibrates M&TE that make pressure, force, displacement, flow, humidity, acceleration, velocity, or temperature measurements. The EE facility services and calibrates M&TE that measures frequency, time, and electrical and magnetic measurements.

Calibration of M&TE may be performed by LLNL calibration laboratories or by outside vendors providing calibration services. Vendors providing calibration shall be required to meet the requirements of MIL-STD-45662, where necessary.

No additional QA records are required in QA files, but such records are filed in the EE and ME calibration facilities.

C-8. Quality Assurance Records

C-8.1. Quality Assurance Records

QA records shall be prepared, archived, and made readily available as evidence that TFG-1 and TFG-2 were specified, designed, constructed, operated, and maintained to meet the quality goals of this QA Plan. They shall be protected and maintained for a minimum of 6 months after completion of the project, prior to being microfilmed and archived for long-term storage.

The QA records specified by this plan do not include all the project records generated in the project. In addition to the QA records, there are microfilmed records are maintained by LLNL Plant Engineering, and contract records are maintained by the LLNL Procurement Department. Although these records are not defined as QA records, they are available for examination.

C-8.2. Filing Systems

QA records required by this plan shall be filed in lockable cabinets in the order given in Table C-2. Before filing, each record shall be numbered and titled according to Table C-2, and stamped with a black ink stamp:

QA RECORD

QA PLAN NO. X-XXX-XX

DATE:___________

A file drawer insert shall be set up and labeled for each file number, and each record shall be placed in a labeled folder or binder and kept in the QAM's office. QA records are not working files, and shall not be so utilized. If files are borrowed, a file checkout system shall be used to track record location and to ensure their prompt return.

C-8.3. Plant Engineering Records

In addition to the separate QA records file of this QA plan, the PEPM, PE, CM, and CI shall organize and maintain working engineering files for the project. These files are not QA records files; they are files normally kept when required for compliance or legal purposes. Records, as specified in the CM Manual and the Construction Inspector's Manual, shall be collected by the CM, CI, and the PEPE, and transmitted by the PEPM to the Standards and Documentation group of PE for microfilming. These files shall be preserved for a period of not less than 6 years after project completion.

C-9. Audits

The PEPM shall arrange for periodic independent audits of the implementation of this QA plan.

QA records to be filed:

(TFG1/G2-18-1) Audit requests and reports.

C-10. References

American Society of Mechanical Engineers (ASME), 1989, NQA-1, *Quality Assurance Program Requirements for Nuclear Facilities*, ASME NQA-1-1989 edition.

MIL-STD-45662, “Calibration System Requirements.”

PEL-01000, “Plant Engineering Policy and Operations Manual.”

Appendix D

Operations and Maintenance Health and Safety Plan

Appendix D
Operations and Maintenance
Health and Safety Plan

This Appendix contains the O&M HASP for TFG-1 and TFG-2.

D-1. Reason for Issue

Safety procedures are required to operate and maintain the air-stripping system, water filtering system, and ion-exchange unit (if needed) for TFG-1 and TFG-2. This HASP also serves as an administrative tool to summarize many of the requirements of the LLNL Health and Safety Manual that are pertinent to TFG-1 and TFG-2 O&M. This HASP supplements the vendor’s operating instruction manuals for the ion-exchange unit (if installed).

D-2. Work to be Done and Location of Activity

D-2.1.

TFG-1, when constructed, will be located east of Building 212, and TFG-2 will be located west of the Building 321 Complex; both locations are in the south central portion of the Livermore Site.

D-2.2.

TFG-1 and TFG-2 are used to treat VOCs and possibly chromium. Ground water containing VOCs and chromium will be extracted from extraction wells utilizing submersible pumps generating from 10 to 20 gpm output.

D-2.3.

The influent passes through two 5-micron filters that have differential pressure gauges across them in the range of 0 to 25 psi.

D-2.4.

Water is forced to pass through an air-stripping tank to remove the VOCs. Acid, carbon dioxide, or other approved additives may be injected into the flow as needed to reduce the formation of precipitates or to achieve a pH within the discharge limits, if necessary.

D-2.5.

VOCs are removed from the water by injecting air into the bottom of the air stripper trays and subjecting the water to intense aeration.

D-2.6.

The effluent passes through an ion-exchange unit (to be installed if necessary) to reduce the concentration of hexavalent chromium at or below the 11 ppb discharge limit (detection limit is 10 ppb).

D-2.7.

The vapor from the stripping tank passes through demister pads to remove the water droplet fraction. The air stream then passes through vapor-phase GAC canisters that trap the VOCs.

D-3. Responsibilities

D-3.1.

Ed Folsom, phone number (510) 422-0389, LLNL pager number 02892, and home phone number (510) 490-7028, is responsible for the safety of this operation and for assuring that all work is performed in conformance with this HASP and applicable sections of the LLNL Health and Safety Manual and Environmental Protection Handbook. In the absence of the responsible individual, Sally Bahowick, phone number (510) 423-6773, LLNL pager number 05565, or Jerry Duarte, phone number (510) 423-2638, LLNL pager number 03180, shall assume these responsibilities.

D-3.2.

Any changes in operations that improve or do not significantly affect safety and environmental controls may be approved by the authorizing individuals in Section D-3.1, and the LLNL Environmental Safety & Health (ES&H) team leader. The responsible individual will ensure that this action is documented in a memorandum. Any changes in the operation that increase the hazard level, introduce additional hazards, or decrease safety shall not be made until a revision to this HASP has been reviewed and approved consistent with the review and approval process of the original HASP.

D-3.3.

Before starting operation, the responsible individual shall verify and document that the operating personnel have read and understand the HASP.

D-4. Hazard Analysis

D-4.1. Pressure Hazard

None is anticipated.

D-4.2. Chemical Hazard

If an ion-exchange unit is used, injury may occur from the unit to personnel exposed to the 1 to 2 Molar sodium chloride solution. Also, injury may occur to personnel exposed to the corrosive substances, such as hydrochloric acid, sodium hydroxide, or other chemicals if they are used to control scaling or pH.

D-4.3. Confined Space

Not applicable.

D-4.4. Noise Hazard

Injury may occur if continued exposure to the aeration system's blowers exceeds the recommended levels.

D-4.5. Electrical Hazard

If an ion-exchange unit is used, injury may occur if the unit panel door is open and contact is made with energized electrical components.

D-4.6. Seismic Hazard

Personnel may be injured during an earthquake due to falling equipment or missile hazards (equipment or materials moving energetically due to seismic forces).

D-5. Hazard Control

D-5.1. Chemical Hazard Control

If used, stored corrosives are doubly contained. Facility operators will follow Health and Safety Manual Sections 21 and 21.05.

D-5.2. Noise Hazard Control

D-5.2.1.

Noise protection is required in the aeration system blower room, if required by LLNL Industrial Hygiene personnel.

D-5.2.2.

The facility operator is required to follow noise safety precautions as outlined in the LLNL Health and Safety Manual, Section 10.08 and Supplement to 10.08.

D-5.3. Electrical Hazard Control

D-5.3.1.

An interlock system and panel doors with keyed locks prevent contact with energized electrical components. Keys to panel door locks are kept in a lock box in TFG-1 and TFG-2.

D-5.3.2.

All personnel will follow safety precautions as outlined in the Health and Safety Manual.

D-5.4. Seismic Hazard Control

Equipment will remain securely bolted inside the shipping container to avoid damage and injury during an earthquake. The shipping container will be secured to a level asphaltic concrete surface or a compacted aggregate-base pad.

D-6. Environmental Concerns and Controls

D-6.1.

Concern: Discharge of untreated ground water.

Controls:

- Interlocks will shut off the system and the flow of air and water if physical damage to the treatment system occurs (as discussed in Section 3.1.3 of the text).
- Scheduled sampling per discharge permit monitors discharge.
- Facility operator inspects the system daily.

D-7. Training

D-7.1.

Basic Facility Operators Courses:

Required:

- HS-0039—SARA/OSHA Training (40-hr course with yearly refreshers).
- HS-0001—New Employee Safety Orientation.

Recommended:

- HS-1620—Standard First Aid.
- HS-1640—Cardiopulmonary Resuscitation (CPR) (CPR certification valid for 1 year).
- HS-5300—Back Care Workshop.

D-7.2.

Facility Operator Courses:

Required:

- HS-4360—Noise Safety.
- HS-0006—Hazardous Waste Handling Practices.
- HS-5245—Lock and Tag Procedure (refresher training required whenever job assignments, equipment or processes that present new hazards, or the Energy Control Procedures change).

Recommended:

- HS-4150—Confined Space.
- HS-4240—Chemical Safety.
- HS-5220—Electrical Safety (required every 5 years).
- HS-5230—High Voltage Safety.

D-7.3.

Training courses identified in this section do not qualify a person to operate the treatment equipment and treatment systems located in treatment facilities TFG-1 and TFG-2. Only the responsible individual identified in Section D-3.1 of this HASP will determine if and when a person is qualified to operate the treatment facilities. Once qualified, each technician's personnel file is updated to reflect their status as a treatment facility operator.

D-7.4.

The responsible individual, or designee, shall ensure that all required training (including on-the-job training if applicable) is completed and documented. Untrained personnel may work under the supervision of a trained person until the required training is completed.

D-8. Maintenance

Items requiring periodic maintenance do not impact the safety of the operation.

D-9. Quality Assurance

Scheduled weekly, monthly, quarterly, and annual sampling of water at various parts in the system ensure compliance and quality.

D-10. Emergency Response Procedures

D-10.1.

In the event of an emergency, facility operations personnel will first dial "911" to report to the Emergency Dispatcher, then administer first aid if necessary to injured personnel. The Emergency Dispatcher uses reserved telephone lines to promptly relay the emergency call to the following members of the LLNL Emergency Response Team:

- Fire Department.
- Security Department.
- Hazards Control Safety Teams.
- Plant Engineering.
- Health Services.

The Emergency Response Team will go to the scene of the emergency immediately. During off-shift hours, the phone numbers of individuals to be notified in the event of an emergency are posted at TFG-1 and TFG-2. The LLNL Health and Safety Plan describes the emergency response procedures.

D-11. References

D-11.1.

Operating manual for the air stripper, and the ion-exchange unit (if installed).

D-11.2. Health and Safety Manual Sections

1. LLNL General Policies and Responsibilities

2. Work Planning and Safety Procedures

10.08 Hearing Protection

21. Chemicals

21.04 Facilities and Equipment

21.05 Handling Solid and Liquid Chemicals

23.00 Electricity

23.01 Introduction

23.02 Biological Effects of Electrical Hazards

23.03 Emergency Assistance and Rescue

23.04 Personal Protective Equipment

23.05 Design and Documentation Electrical Equipment

23.06 Training Requirements for Electrical Work

23.10 General Practices for Work on Electrical Equipment

23.13 Work on Other Electrical Apparatus and Systems

23.20 Clearances and Illumination for Electrical Enclosures

23.21 Power Disconnect Points

23.23 Extension Cords

23.30 Portable Electric Tools and Equipment

23.35 Power Supplies

23.36 Microwave and Electromagnet Sources

23.37 Electromagnets and Inductors

23.38 Batteries

23.39 Capacitors

26.14 Working in Confined Spaces

D-11.3. Electronics Engineering Department—Electrical Safety Policy, LED-61-00-01-A1A

D-11.4. Health and Safety Manual Supplements

11.07 Personnel Safety Interlocks

10.08 Noise–Its Measurements, Evaluation, and Control

26.13 General Lockout and Tagout Procedure

26.14 Working in Confined Spaces

D-11.45 Environmental Protection Handbook

D-12. Reviewers

The following are reviewers for this O&M HASP:

- Facility Supervisor.
- Section Head or Group Leader.
- Hazard Control Safety Team 4.
- Individual assigned responsibility for safety.
- Division/Department who authorized HASP.
- Supervisor of matrixed technical personnel.

Appendix E

TFG-1 and TFG-2 Sampling Procedures

Appendix E
TFG-1 and TFG-2 Sampling Procedures

Water samples will be collected prior to and following treatment, and prior to discharge to a storm drain and/or the Recharge Basin. Ground water discharged to a storm drain will be collected according to the schedule outlined in WDR Order No. 91-091 and presented in Table 11 of this report. Ground water discharged to the Recharge Basin will be collected according to the schedule outlined in WDR Order No. 88-075 and presented in Table 12, if approved by the RWQCB. Prior to collecting a sample, the office preparation procedures described in SOP No. 2.6— "Sampling for Volatile Organic Compounds" and SOP No. 4.2— "Sample Control and Documentation" will be followed (Rice *et al.*, 1990).

Samples will be collected from the TFG-1 and TFG-2 designated sampling stations shown on Figures 10 and 11. The influent and effluent samples will be collected by opening the valve at the sampling port and allowing water to flow through it for about 15 seconds. A bottle will be introduced into the flow stream and filled. If the bottle is not certified clean, it will be rinsed first with the water to be sampled. Any untreated water flowing through the valve during sampling will be captured with a bucket and returned to the system for treatment.

A specific sample container is used, depending on the analysis. In addition, some analyses require sample preservation. Such requirements for each analysis are described in SOP No. 4.3— "Sample Containers and Preservation" (Rice *et al.*, 1990). Samples are then packaged and shipped to a certified analytical laboratory according to SOP No. 4.4— "Guide to the Handling, Packaging, and Shipping of Samples" (Rice *et al.*, 1990).

Results of the treatment facility sampling are discussed in the self-monitoring section of *LLNL Livermore Site Ground Water Project Monthly Progress Reports*.

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NOTICE: Plates 1 & 2 exist only in hard copy. They can be found in ERD Trailer 4302's Library.